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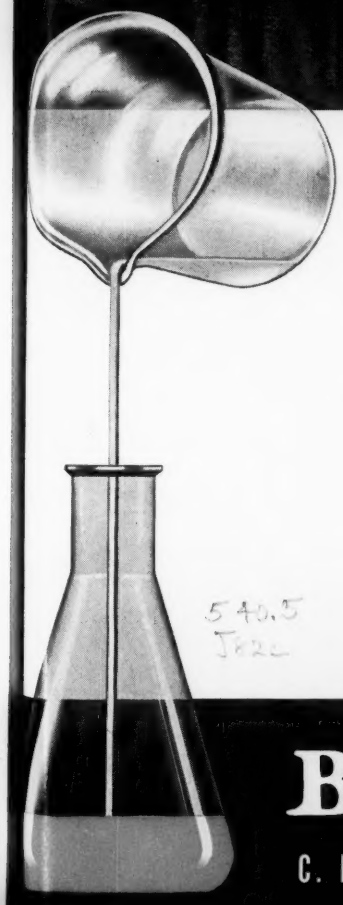
1942

CHEMICAL EDUCATION



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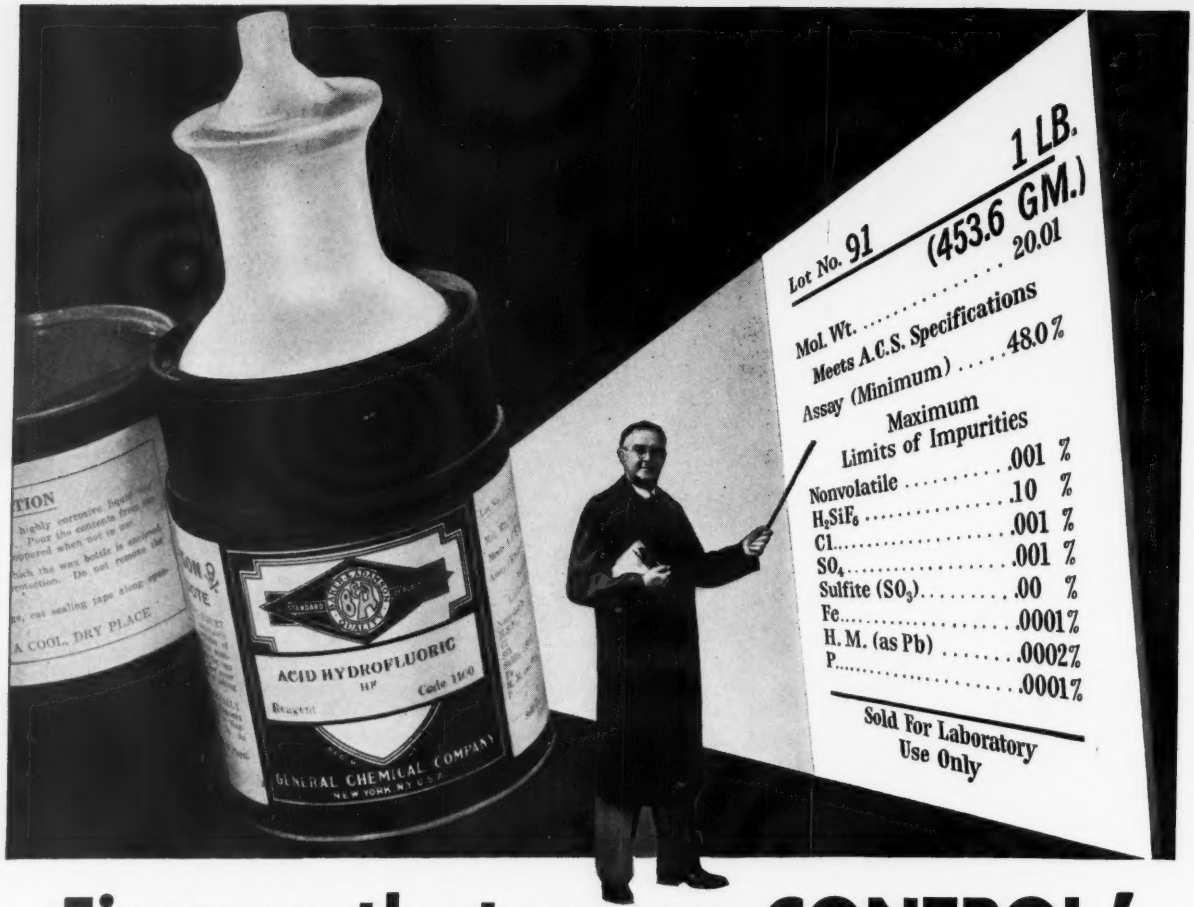

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INCORPORATING THE REPORT OF THE NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

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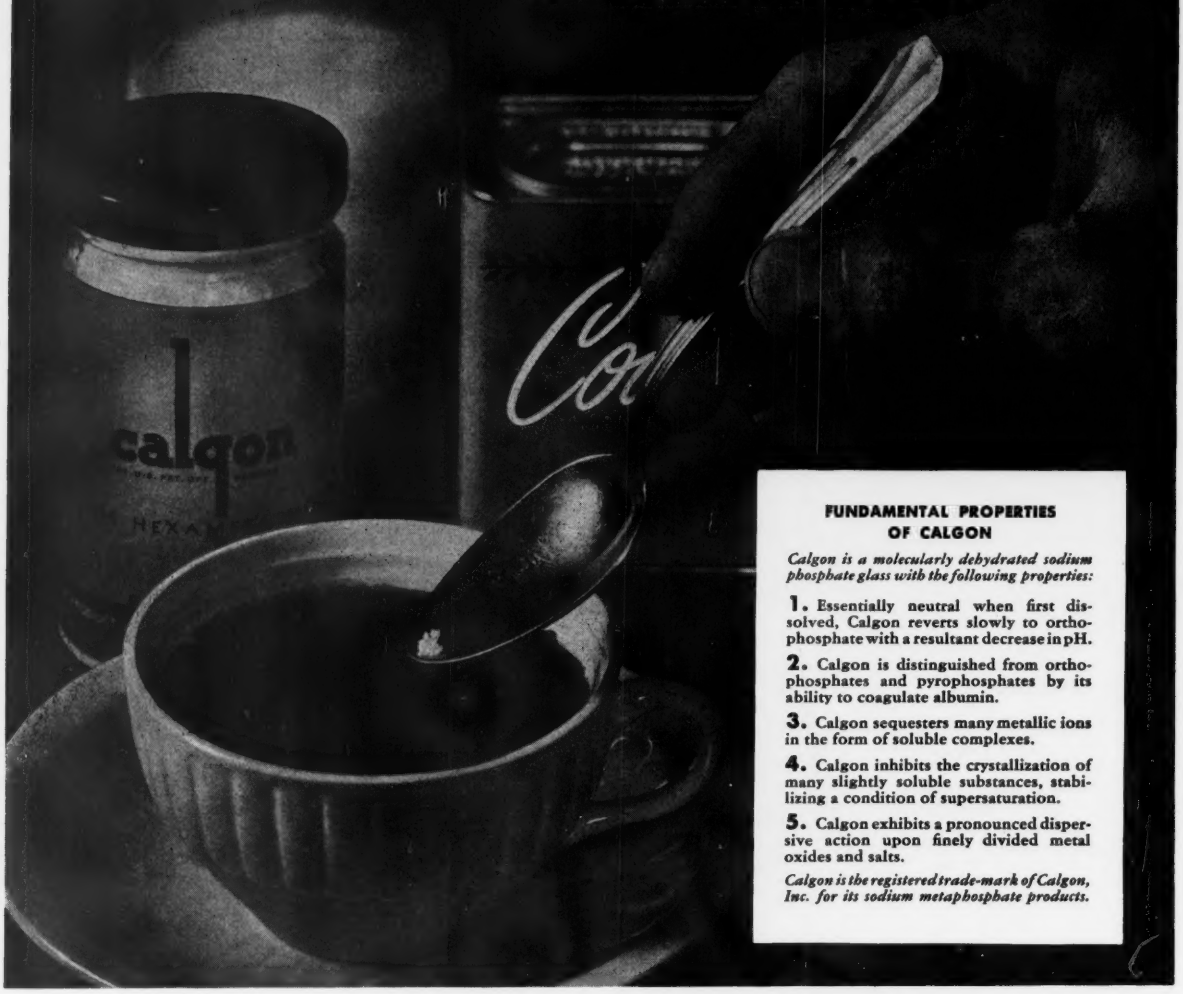
EVEN A CUP OF COCOA

will be Smoother for a Pinch of Calgon



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Nicolas Leblanc (1742–1806)

Contributed by Ralph E. Oesper, University of Cincinnati

Bronze statue of Leblanc in the courtyard of the Conservatoire des Arts et Metiers, Paris. The artist was Hiolle. The funds were provided by international subscription. The unveiling took place on June 28, 1887. A replica was later placed at the Porte de Paris in St. Denis. No actual likeness of Leblanc is recorded but details of his appearance given by his daughter and friends may be found in Anastasi's biography.

(See page 567)

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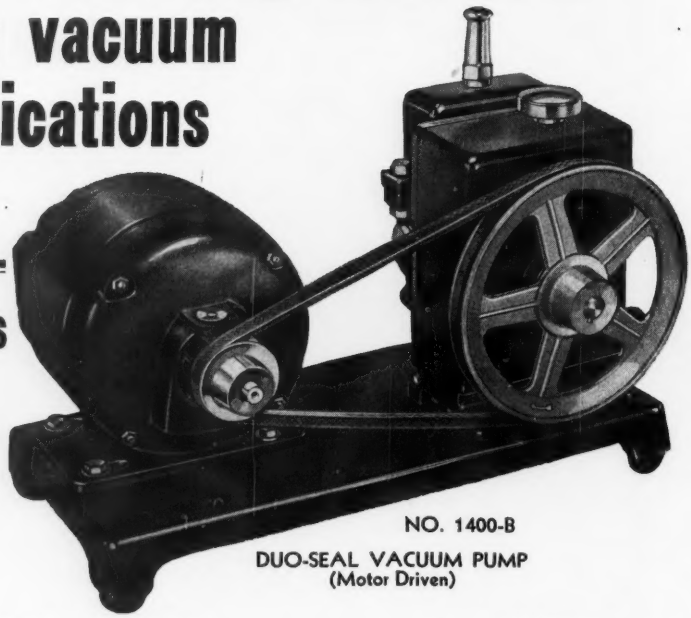

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Editor's Outlook

AS THIS is written the manpower muddle is far from being straightened out, and it is still a matter of vital concern to the chemical profession as well as the educational world. The Army is said to have a "plan" for the higher educational institutions to carry out, as their part in the war order. No one knows what the plan is, but it seems that the colleges will take it and like it—or else.

Naturally, the colleges want to do their part, and some of them have already had rather definite ideas of what their part could and should be. Quite possibly they may learn that it is to be something very different. It is incomprehensible, however, that any plan will prevail which completely cuts off the flow of young men into the vital and necessary professions. Even so, there still remains the question of chemistry's place among the vital professions.

In the discussion going on there is a strange and disturbing report which crops up now and then: The Army believes that there are already enough chemists.

Enough for whom? For the Army, perhaps so, just now. But you would think that no one is worried or concerned about this war but the Army. And when it comes to saying, "Enough," the Army's record isn't too good. We seem to remember that the expansion of the aluminum industry was thought to be enough several times until finally the ceiling was made virtually unlimited. The Army's whole conception of production seems to have been "too little and too late."

We suggest that the same is true of the supply of chemists. Who are responsible for our ability to make 200,000 barrels of aviation gasoline per day? Chemists. Who are going to make the million tons of synthetic rubber (we hope!) and fabricate it into the many necessary articles? Chemists. Who have been developing the aluminum industry to its capacity of a million tons a year? Chemists. How much steel would we be able to produce, especially of the fine alloy varieties without—chemists? Who found out how to make almost limitless quantities of toluene from petroleum, for TNT? Chemists. Who gave the Army the powerful antiseptic drugs for wounds; the excellent fabrics which substitute for Japanese silk in parachutes; the vitamins and condensed foods which bolster the health and morale of the troops; the water-repellents which keep their clothes dry; the mosquito and insect repellents which protect them by day and by night; the plastics which serve a thousand uses, from bomber windows to crash helmets; the motor fuels which surpass all others in the world in power and quality; the lubricants which permit motors to run at higher and more efficient temperatures? All these things and many, many more are the willing contributions to the Army from—chemists.

"Thanks, boys, but we have enough of all these things. Get into your uniforms now and do something *really* useful."

Had scientists, including chemists, not been on the job for many years our heroic Army would not have been able to make its stand in Bataan and on Corregidor, our Navy would have been sunk at Midway and in the Coral Sea. All this has been gone over so many times that it is more than a trifle bromidic.

Of course, no one has suggested that we close up scientific research for the duration. But in view of its vital effectiveness we should not be satisfied with anything less than our *maximum* capacity in this field. To shut off the possible supply of new inventive minds is like closing down some of our blast furnaces.

Very likely some of the confusion in thinking about the vital need of chemists in the present emergency arises from failure to comprehend what a chemist really is. The layman vaguely remembers some expression about "the chemist and his test tubes," which didn't impress him very much, or he recollects that he recently went into a "Chemist's Shop" where he bought a toothbrush and a chocolate ice cream soda.

We think that the Army is too intelligent to make any such error, but we can easily imagine a general not knowing that a chemist is oftentimes the man who operates the plant which turns out the stuff which the Army is hollering for. Don't think that the chemist is always immured in his study or puttering around in a tiny laboratory. We have never quite agreed on the difference between a chemist and a chemical engineer. Some of our colleges and universities prefer to make no distinction in their own training and their "chemists" get into overalls and compete in industry with the "chemical engineers" from other institutions. And it should be noted that the American Chemical Society invariably uses both designations in describing its membership.

The Army's chemical thinking is naturally centered largely on its own Chemical Warfare Service. In outlining, above, the contributions of the chemist to war preparedness, we omitted all reference to this field, since it is so obvious. Thus far in the war, action of the Chemical Warfare "front" has apparently been rather slow, although considerable use has been made of incendiaries and screening smokes, which belong in this category. But one wonders if there would be the same indifferent attitude toward chemists and their training if gas warfare should suddenly break loose. We rather suspect that there would be a frantic call to put every possible chemist to work, in the fear that some possible development might be missed, that our enemies might get the jump on us by sneaking one of those "mystery gases" out of the cupboard, which are always suspected of lurking around somewhere but never seem to be found.

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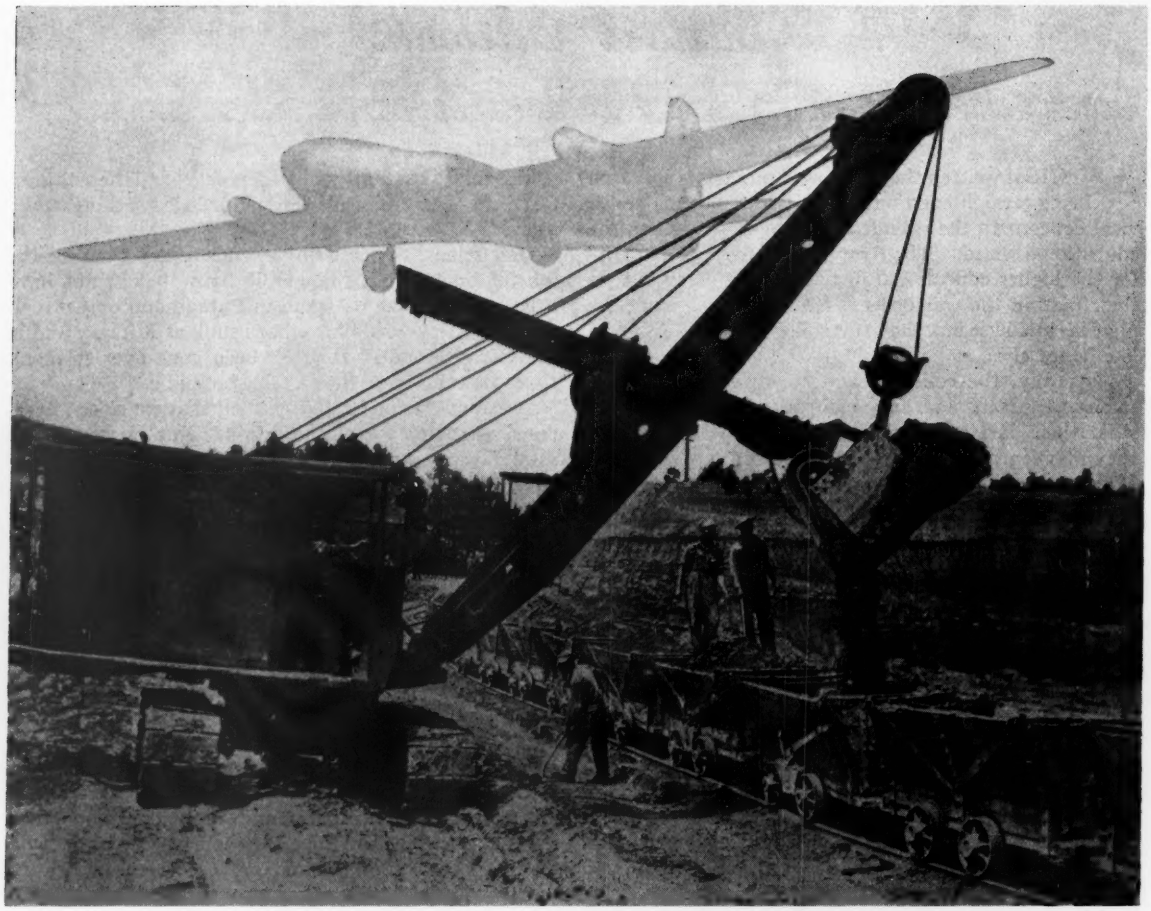


The earth bound aluminum being dug out here may soon be air-borne, winging its way for thousands of miles on a mission of destruction.

The Light Metals: Aluminum and Magnesium

JOHN ST. PETER

Aluminum Company of America, Pittsburgh, Pennsylvania

Aluminum

ALTHOUGH aluminum is the most abundant of all the metallic elements found in the earth's crust, it is nonetheless one of the most difficult to extract from Nature's grasp. Up until about one hundred years ago no one had ever succeeded in separating metallic aluminum from the compounds in which it occurs. Many scientists of that time did not even suspect the metal's existence.

Hans Christian Oersted, a Danish physicist and chemist, is credited with being the first man to isolate aluminum. In 1825 he announced to the Royal Danish Academy of Sciences that by heating aluminum chloride with potassium amalgam he had obtained a grayish metallic substance. Other scientists, among them Frederick Wöhler of Germany and Henri Sainte-Claire Deville of France, also devised chemical processes for reducing aluminum ores, but they were complicated and costly. The metal brought $545 a pound in 1852. Seven years later the price had been reduced to $17 a pound, but it still ranked as a "precious" metal.

It was in 1886 that the electrolytic process of reducing aluminum from its oxide was discovered by a 22-year-old Ohio boy named Charles Martin Hall.

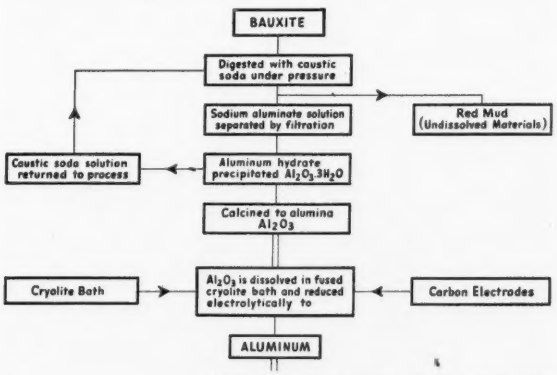
Through privately conducted experiments he found that molten cryolite (a sodium aluminum fluoride mineral) would dissolve aluminum oxide, thus making it possible to pass an electric current through the solution. The electrolytic action separated the oxide into its component elements—aluminum and oxygen. Aluminum settled to the bottom of the crucible; the oxygen, being a gas, combined with the carbon of the anode and escaped.

Hall's process was the first to make pure aluminum available on a commercial scale, and today electrolysis is still the basic principle behind aluminum production throughout the world. By 1891 the price of aluminum had dropped to less than one dollar a pound. It since has gone constantly lower, and sells at present for but 15 cents a pound in ingot form.

It is well to mention at this point a peculiar historical coincidence. At the time of Hall's discovery of the electrolytic process in the United States, a young French scientist named Héroult was making the same discovery in Europe. Hall and Héroult had never heard of each other, but independently developed identical processes for producing aluminum at low cost.

Aluminum Ores. Unlike many other metals, such as gold, copper, and iron, aluminum is never found in the metallic state. It is always combined with other elements, and its principal compounds are the silicates and oxides. Every clay bank and practically all of our common rocks contain some aluminum, yet the cost of separating the metal from these low-grade sources is so high that at present it is obtained in the United States from only one mineral—bauxite—which is rich in aluminum.

In the United States there are bauxite deposits in Arkansas, Alabama, Georgia, Mississippi, Tennessee, and Virginia, but a large part of the bauxite used in this country is brought in from Surinam (Dutch Guiana), South America. Bauxite itself is a compound of aluminum, oxygen, and chemically combined water—a hydrated aluminum oxide. Silicon oxide, iron oxide, and titanium oxide are also present in bauxite as impurities and must be removed.

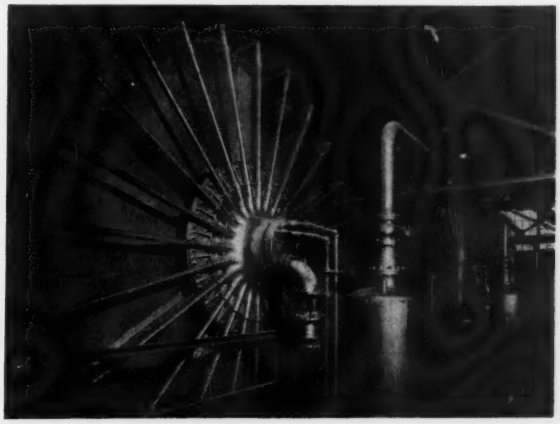

BAUXITE
Digested with caustic soda under pressure
Sodium aluminate solution separated by filtration
Red Mud (Undissolved Materials)
Caustic soda solution returned to process
Aluminum hydrate precipitated $Al_2O_3.3H_2O$
Calcined to alumina Al_2O_3
Cryolite Bath
Al_2O_3 is dissolved in fused cryolite bath and reduced electrolytically to
Carbon Electrodes
ALUMINUM

Courtesy of the Aluminum Company of America

DIAGRAMMATIC PRESENTATION OF ALUMINUM REDUCTION PROCESS

Processing. In order to separate the impurities from bauxite, the ore is first subjected to a processing operation. It is dumped into great crushers, sprayed with water, washed and rewashed to remove as much clay as possible, and the water is then drained off. When nearly dry, the bauxite is stored in ore bins and from there is fed into drying kilns to drive off remaining moisture.

Many metals are produced directly from their ores and purified afterward, but aluminum can only be produced in the pure state by removing undesirable



Courtesy of the Aluminum Company of America

FILTERS WHICH REMOVE MOST OF THE UNCOMBINED MOISTURE FROM ALUMINUM HYDROXIDE BEFORE KILN HEATING

components from the ore itself. Impurities in bauxite are separated from the aluminum hydroxide by a chemical process and the hydroxide calcined to pure aluminum oxide, or alumina. It is the alumina that is used in the Hall process of reduction.

The most generally used method of refining bauxite is the Bayer process. The crushed, washed, and dried bauxite is ground into a powder, mixed with a hot solution of sodium hydroxide (caustic soda), and pumped into large pressure tanks, called "digesters." The caustic soda dissolves the aluminum hydroxide out of the bauxite to form a sodium aluminate solution:

$$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$$

Since the impurities in the ore are not affected by the caustic, they remain in solid form and are removed from the sodium aluminate solution by filtration, being left behind as a red mud residue. The importance of the washing procedure, which removes clay from the bauxite before the ore is subjected to the Bayer process, becomes apparent when it is realized that clay is attacked by the caustic soda solution to form sodium silicate, which in turn reacts with the sodium aluminate to produce an insoluble sodium aluminum silicate. Thus, the silica in clay not only decreases the amount of alumina recovered from the bauxite but also consumes the caustic soda, which otherwise could be reused, as we shall see.

Courtesy of the Aluminum Company of America
ALUMINUM, TAPPED INTO THIS LADLE FROM AN ELECTROLYTIC CELL, IS CAST INTO PIGS

After the sodium aluminate solution passes through the filters, it is pumped into precipitating tanks. Upon cooling, fine crystals of aluminum hydroxide settle out of the solution:

$$NaAlO_2 + 2H_2O \longrightarrow Al(OH)_3 + NaOH$$

After precipitation is completed, the aluminum hydroxide crystals are transferred to other tanks and washed to remove the caustic. The caustic solution is then pumped back into the digesters to treat a new batch of bauxite. The aluminum hydroxide, which is simply aluminum oxide (alumina) chemically combined with water, is heated white-hot in kilns. The chemically combined water is driven off, and the character of the material is altered so it will not reabsorb moisture from the air:

$$2Al(OH)_3 + \text{heat} \longrightarrow Al_2O_3 + 3H_2O$$

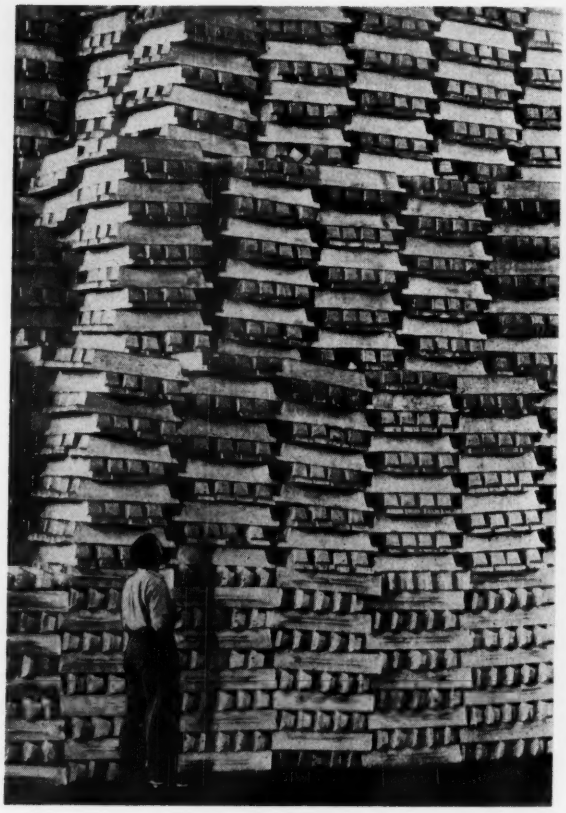
Two pounds of aluminum ore are required to produce one pound of alumina—the powdery white chemical (Al_2O_3) which is now ready for reduction to aluminum.

Reduction. The reduction of alumina to aluminum is accomplished in an electrolytic cell. The cryolite bath material is first introduced into the cell and fused by the electric current. Alumina is added and, as the current passes through, metallic aluminum is deposited on the cell bottom while the oxygen combines with the carbon of the anodes and escapes as a gas.

The molten layer of aluminum is tapped from the bottom of the cell into large ladles and cast into pigs. The process is continuous. As the cryolite bath material becomes exhausted in alumina, more alumina is added and the cycle of operations is repeated.

The metal, removed from the electrolytic cell, contains some dross and bath material, however, so pig aluminum is not sold for commercial fabricating purposes. It is first remelted and the non-metallic impurities removed. During this remelting operation, alloys also are added if metal other than pure aluminum is desired, and the material is then cast into ingots for use by industry.

Aluminum in Use. No other metal can be obtained in as many different forms as aluminum, and it is adaptable to every known metal-working process. Different types, sizes, and shapes of ingots are produced according to the use for which they are intended. Aluminum is drawn into wire, rolled into bar, rod, and a variety of large structural shapes. It is stranded into



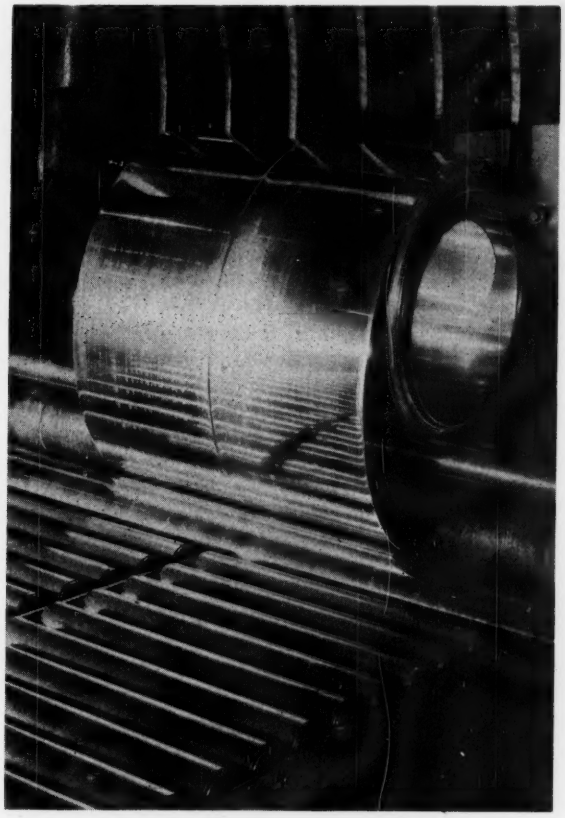
Courtesy of the Aluminum Company of America
A STOCK-PILE OF ALUMINUM PIGS

cable for electric transmission lines. It is extruded (pushed through dies under enormous pressure) into many structural and ornamental forms, and into tubes of various shapes and sizes.

Aluminum is forged, pressed, and cast. Screw-machine products, rivets, nails, powder for aluminum paint and for fireworks—all are made from it. It is rolled into plate, sheet, and foil from which countless familiar items are manufactured. Radio transformer shields, tooth-paste tubes, and similar containers are formed from aluminum by impact extrusion. It can be riveted, arc welded, torch welded, spot welded, seam welded, and butt welded. Aluminum machine screws, bolts, and nuts may be employed in joining the various parts of light metal structures. It may be stamped, drawn, spun, turned, and formed on any of the machines usually found in sheet-metal shops.

Properties. Aluminum is particularly well known for its lightness. It has a specific gravity of 2.7, about one-fourth to one-third that of the other common commercial metals. Its atomic weight is 27; its melting point, 1220°F. (660°C.). Among its other inherent characteristics are non-toxicity, a high degree of resistance to corrosion, high thermal and electrical conductivity, easy workability, and excellent reflectivity for heat and light. The tensile strength of aluminum, especially when alloyed with small quantities of certain other elements, makes it highly suitable for structural purposes. Cold working of the metal, plus heat treatment, will raise the tensile strength of some aluminum alloys to within the strength range of structural steel.

Courtesy of the Aluminum Company of America
ONE OF THE GREAT HAMMERS USED IN MAKING ALUMINUM FORGINGS



Courtesy of the Aluminum Company of America
SHEET ALUMINUM BEING COILED AFTER PASSAGE THROUGH ROLLING MILL

Applications. Commercially the first important development of aluminum came in 1890 when it was found that the metal's properties suited it ideally for making cooking utensils. Shortly thereafter the use of aluminum conductors for electric transmission began, and more than one million miles of aluminum cable, steel reinforced, have been put into service since then. Aluminum is also widely used as electrical busbar conductor in industry.

For the duration of World War II, all aluminum production in the United States will go to the war effort. It is the most important raw material in the fabrication of wartime aircraft and is widely used in the manufacture of battleship fittings, field kitchen equipment, and hundreds of the accoutrements necessary to provide proper equipment for our armed forces.

Peacetime production of aluminum products has included important items for the automotive industry, decorative and structural metal for architectural uses, household appliances, streamlined trains, transport aircraft, industrial machinery, packaging materials, electrical conductors, chemical equipment, gasoline truck tanks, railroad tank cars, furniture, cooking utensils, giftware, paint, and countless other applications.

Doubtless the return of peace and the resulting availability of tremendous new production facilities will infinitely broaden the scope of aluminum's uses.

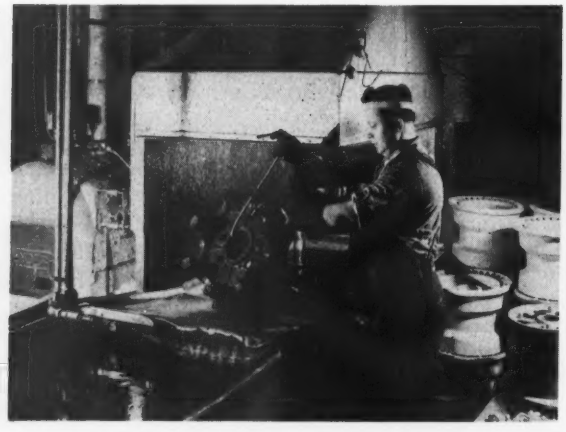
MAGNESIUM

THE THIRD most abundant common metal in the earth's crust is magnesium, which weighs approximately one-third less than aluminum and is the lightest of the structurally useful metallic elements. It is never found in Nature as a free metal. Its chronological history follows closely that of aluminum. Sir Humphry Davy, the British chemist, isolated magnesium for the first time in 1808. Bussy, a French scientist, identified it as an element in 1829, and it was first recovered by an electrolytic process on a practical working basis in 1896—just ten years later than Hall's discovery of a similar process for reducing aluminum.

Only in comparatively recent years has magnesium emerged from the stage in which it was simply a laboratory curiosity. The electrolytic process for its recovery was developed in Europe, and commercial production in the United States did not begin until the time of the first World War. Europe's sources were then cut off as far as American importation was concerned, and domestic industry began manufacturing magnesium for this country's needs in 1915.

The price of magnesium at that time was approximately five dollars per pound. Steady growth of the magnesium demand saw American production rise rapidly—from 87,500 pounds in 1915 to millions of pounds annually at present—and the price drop to less than 23 cents per pound.

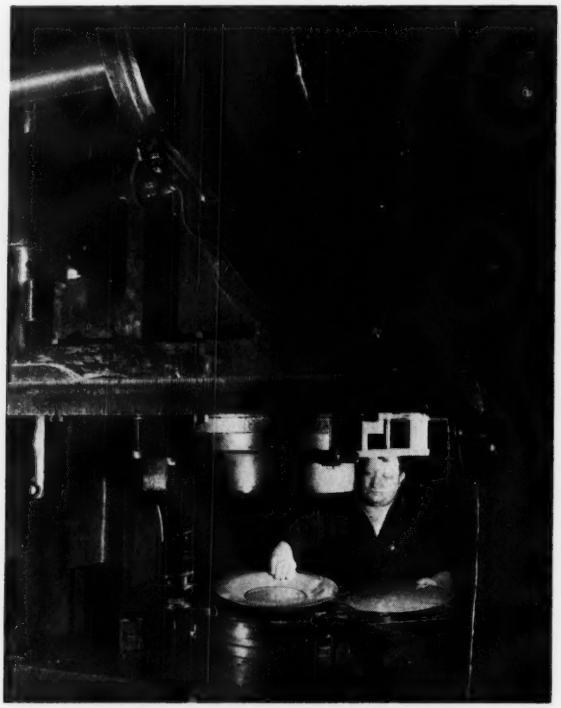
Sources of Magnesium. The raw materials from which magnesium may be extracted are very plentiful throughout the world. Among the more important sources are: sea water, underground brine, salt lakes, potash, and other saline operations; and such minerals as magnesite, brucite, dolomite, carnallite, and many others.



Courtesy of the American Magnesium Corporation

A MAGNESIUM SAND-CASTING WHICH HAS JUST BEEN DIPPED IN A BATH OF COATING MATERIAL TO PREVENT CORROSION OF THE METAL

Sea water contains about 0.14 per cent magnesium and offers an unlimited source of supply. Great Salt Lake in Utah, whose waters contain 0.6 to 3.2 per cent magnesium, and other similar closed basins are potential sources that remain to be tapped. Large magnesite ($MgCO_3$) deposits are found extensively in Washington, California, and Nevada; brucite (MgO) deposits in Nevada; dolomite ($MgCO_3 \cdot CaCO_3$) and high-magnesia limestone deposits in at least a dozen states.



Courtesy of the American Magnesium Corporation

A COLD-FORMING PRESS MAKING BRAKE-WHEEL COVERS FOR AIRCRAFT LANDING GEAR. THE MATERIAL IS BLANKED MAGNESIUM SHEET

Reduction. In the United States, nearly all magnesium production to date has been by the electrolysis of molten magnesium chloride crystals. These crystals are obtained from (1) magnesium chloride hexahydrate, which is found in underground brine and extracted by a complicated dehydration process; or (2) magnesium hydroxide, which is separated from sea water by reaction with lime and is then converted into the chloride.

New processes, designed to augment domestic magnesium production by utilizing ore instead of brine or sea water as raw material, are at present being put into experimental operation in the United States. Perhaps they will soon be out of the experimental stage. One of these methods is called the ferro-silicon process. Another is the thermic process. In both of these methods, heat instead of electrolytic current is the means of reduction.

Courtesy of the American Magnesium Corporation
COLD ROLLING OF MAGNESIUM SHEET

In the thermic process, magnesite ore (which contains magnesium combined with oxygen) is mixed with carbon, and the mixture is heated in an electric-arc furnace at high furnace temperatures (over 4000°F. or 2200°C.). The oxygen is taken up by the carbon to form carbon oxides, and the elemental magnesium is vaporized. The mixture of magnesium vapor and carbon oxides must then be cooled quickly, since at intermediate temperatures the oxygen would again combine with the magnesium. This cooling is accomplished by passing the vapor through a flue, injecting large volumes of hydrogen to prevent reoxidation of the magnesium, and carrying the mixture into a low temperature chamber.

At this time the magnesium, condensed in the form of powder, is full of carbon dust and small quantities of other impurities. The metal is removed by distilling the mixture in a partial vacuum. Magnesium vapor is again condensed and the resultant small metallic pellets dropped immediately into hydrocarbon oil to prevent oxidation. Finally it is separated from the oil, remelted, and cast into ingots.

The ferro-silicon process recovers magnesium from dolomite ore (calcium magnesium carbonate). Burned dolomite lime is mixed with crushed ferro-silicon and the mixture is placed in sealed metal retorts. A vacuum is maintained in the retorts, and heat is applied externally. Metallic magnesium forms in a solid crystalline mass. It is subsequently melted (under a fluxing material) and poured into ingot form. Natural gas is used as fuel for heating the retorts during the chemical reaction in most ferro-silicon process projects at present, although electrical heat was employed in some of the original experiments.

Available Forms and Properties. Magnesium is commercially available in many forms. Among these forms are: sand, permanent-mold and die castings; cast ingot, suitable for casting, rolling, extrusion, or forging; and wrought metal, such as plate, sheet, extruded bar, extruded molding and structural sections, and forgings. This phenomenally light metal is coming into use more and more wherever elimination of weight is a prime factor.

Magnesium alloys have extremely good machining characteristics. Riveting is one of the best ways for making structural joints in magnesium, but it also can be welded readily by torch or electric-resistance welding methods. With but minor variations the magnesium sheet alloys are easily handled on familiar sheet metal shop equipment.

The outstanding physical characteristic of magnesium is its extremely light weight in comparison with other metals, being one-fourth to one-fifth the weight of such common metals as iron, steel, zinc, copper, and brass. Its specific gravity is 1.7; its atomic weight is 24.3; its melting point, 1205°F. (651°C.). Pure magnesium has relatively low strength, but by alloying it with small amounts of other metals—particularly aluminum, zinc and manganese—alloys have been developed which

Courtesy of the American Magnesium Corporation
MAGNESIUM "WARP BEAMS" USED IN THE TEXTILE INDUSTRY

have excellent mechanical properties and high strength-to-weight ratios. Heat treatment will also add considerably to magnesium's structural strength.

Magnesium alloys are resistant to attack by alkalies and many organic chemicals, but are attacked by acids of any strength except pure hydrofluoric and chromic acids. Salt solutions corrode the metal, and to protect magnesium alloy surfaces exposed to salt air and moisture they should be coated chemically and painted.

Applications. At present, due to wartime requirements for light metals, almost all magnesium produced in this country is being used in the construction of aircraft parts, particularly landing wheels, engine parts and structural members. In past years this metal enjoyed considerable popularity in the manufacture of reciprocating units in rapidly moving machinery, and for parts of portable tools, sewing machines, vacuum cleaners, and office equipment such as typewriters, calculators, addressing machines, and the like. Enormous new vistas had just started to unfold before the magnesium industry when World War II stopped production of all products except those needed for war. There will doubtless be a considerable broadening of magnesium's uses with the return to peacetime production plans.

COÖPERATIVE COMMITTEE ON SCIENCE TEACHING

IN THESE days the training of the youth of America in mathematics and the physical sciences in the secondary school is receiving considerable attention. Plans are going forward on many fronts to remedy a situation whose factors are much wider in scope than just the lack of good teaching. Among the groups working on this problem is the Coöperative Committee on Science Teaching, consisting of two members each from the American Association of Physics Teachers, the American Chemical Society, the Mathematical Association of America, the Union of American Biological Societies, and the National Association for Research in Science Teaching.

The first published report of this committee appeared in the October issue of *School Science and Mathematics*. The report presents two areas in which the committee makes definite recommendations: in the matter of college preparation of high-school science teachers and in the certification of high-school science teachers. The committee realizes that the problem is most clearly that of the small school, and its recommendations are made with that in mind. Much science is being taught today by teachers who are poorly qualified by preparation and training for the job. In small schools especially a teacher is required to teach several of the sciences or all of them, while his preparation may have been only in one or two narrow science fields or scattered thinly over a wide science field.

Reprints of this report are available and may be obtained by writing to the chairman of the Committee, Dr. Robert J. Havighurst, University of Chicago, to Dr. B. S. Hopkins, University of Illinois, Urbana, Illinois, or to Martin V. McGill, 5439 Kimbark Ave., Chicago, Illinois.

ADDITION

THE FOLLOWING additions to the miscellaneous references at the end of the article by Elving entitled "Courses in Advanced Analytical Chemistry, I. Texts for Courses in Applied or Technical Analysis"[1] were received too late for inclusion. Those interested will want to add these to the list previously published.

JUDD AND KELLEY. *Method of Designating Colors.* 1939. 30 pp. 10¢ (Bureau of Standards, Research Paper 1239.) C 13.22/a: 1239. The specification of color is fully covered through a description of the surface-color solid and of the use of the Munsell Book of Color in evaluating the colors of opaque objects. The excellent illustrations are very helpful. The use of this booklet would acquaint the student with one of the most successful schemes now in use for the designation of color.

(*GFS Pamphlet Publication*) Free (G. Frederick Smith Chemical Co.). This well-known series is probably the outstanding example of the monograph material pertaining to analytical chemistry which is being published by chemical and apparatus supply houses. The applicability of these publications in different fields of technical analysis as laboratory procedures or as reference material is evident from the topics covered, including monographs on the analytical procedures utilizing ceric sulfate, perchloric acid, mixtures of perchloric, sulfuric and phosphoric acids, iodic and periodic acids and their salts, ortho-phenanthroline as redox indicator, organic reagents like cupferron and the dioximes, dehydrating agents, and the cathode ray tube potentiometer. The topics covered include all phases of applied inorganic and organic analysis.

(*Methods of the Chemists of the United States Steel Corporation.*) Various prices (Carnegie Steel Co., Bureau of Technical Instruction). Under the foregoing general title several books have been published, summarizing the experience of practical steel works chemists as regards the best methods for the sampling and analysis of various types of materials. At least one of these publications has been taken over by a commercial publisher. The titles issued cover coal, coke and by-products, iron and manganese ores, pig iron, carbon and alloy steels, gases, and other material of metallurgical interest. The suitability for a particular course of any of these publications can best be decided by personal examination.

[1] J. CHEM. EDUC., November, 1942.

Teaching of Catalysis[1]

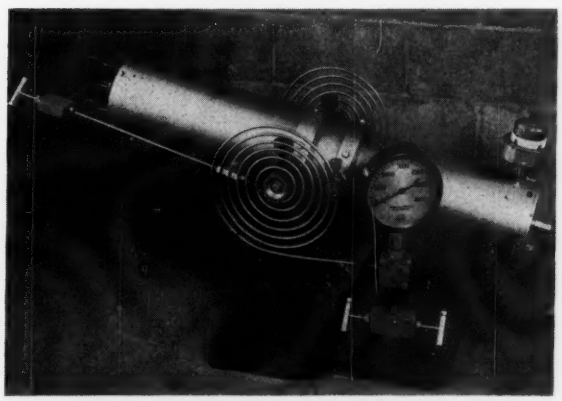
V. I. KOMAREWSKY

Illinois Institute of Technology, Chicago, Illinois

WITH THE ADVENT of the second World War, the vital significance of catalysis, long recognized for its many uses in industry, has been sharply emphasized by the multiple demands made upon chemical developments by the armed forces. The production of high explosives, aviation fuel, and synthetic rubber number among the important reasons why the catalytic processes have become a necessary part in the education of the modern student of chemistry. The present situation in the field of catalysis is characterized by at least three prominent factors. In the first place, catalytic reactions have an extensive and important place both in science and industry; second, the technics employed are difficult ones; and third, very little is understood of the mechanism and underlying theory.

It was with realization of these facts that a graduate course in "catalytic reactions and their industrial application" was organized seven years ago at Illinois Institute of Technology. The purpose of this course was to acquaint the students with the most important catalytic reactions and their industrial application and to teach them to perform the most typical reactions in the laboratory with emphasis on the preparation and handling of catalysts.

Through the generous support of industry, the catalytic laboratory acquired a wide variety of equipment such as electrically heated catalytic furnaces, with automatic temperature control, high pressure autoclaves and pumps, high precision distillation column for gases and liquids, Goeckel gas adsorption apparatus, and so on.



HIGH PRESSURE AUTOCLAVE (SHAKING). "AMINCO" TYPE

[1] Paper presented before the Chemical Engineering Division of the Society for the Promotion of Engineering Education. New York, June 29, 1942.

Because of the lack of a single, generally accepted theory explaining the mechanism of the catalytic action, it was expedient to adopt the following system in the presentation of the theoretical part of the course.

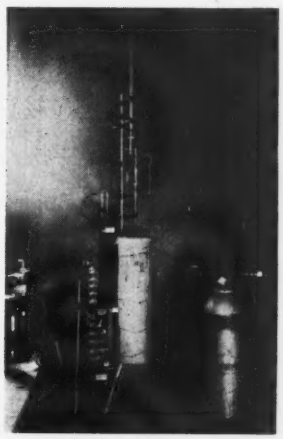
First, the students were taught the experimental facts involved in the particular reaction under discussion.

Second, the various existing theories were presented and analyzed.

Third, the experimental work supporting these theories was studied.

Fourth, a general summarization was offered to which was added the conclusions drawn by the students in the classroom.

Finally, the last few lectures were devoted to a critical survey of the various theoretical approaches to the elucidation of the catalytic action in view of the total course material. That this system was a satisfactory one has been evidenced by the problems for future research often conceived directly during these discussions.



VERTICAL, ELECTRICALLY HEATED, CATALYTIC FURNACE WITH AUTOMATIC TEMPERATURE AND LIQUID FLOW CONTROL

The course consisted of 6 hours (2 of lecture and 4 of laboratory) during two semesters, with a credit of 4 semester hours. The average class contained 10 students. Due to time limitations the course was confined to organic catalytic reactions.

The introductory lectures classified the material to be presented and defined terms to be used in the course, such as catalysis, catalytic reaction, chemical induction, catalyst, carrier, promoter, and poison. Catalytic reactions were divided into homogeneous (gaseous, molecular, ionic) and heterogeneous, with a short discussion of surface phenomena.

The introduction was followed by a brief historical survey, with particular care to select the work which decisively influenced the future development of catalysis and gradually formed the modern conception of catalytic phenomena. The following work of the past was brought to the attention of the students:

1. Clément and Desormes. Lead chamber process; first catalytic reaction by forming intermediate compounds with the catalyst.
2. Davy and Döbereiner. Contact reactions on platinum.
3. Berzelius. Term "catalysis" and separation of catalytic reactions into a special branch of chemistry.

4. Mitscherlich. Term "contact catalysis" and emphasis on the importance of contact between catalyst and substrate.
5. Mercer and Schönbein. Complexity of the mechanism of chemical reaction.
6. Deacon. First catalytic reaction used as such in industry.
7. Ostwald, Gibbs, Bredig, Zelinsky, Mittasch, Haber. Catalytic reactions from the standpoints of thermodynamics, kinetics, and equilibrium.
8. Sabatier. Catalytic reactions in the presence of metals or metal oxides, and the discovery of hydrogenation.
9. Ipatieff. Specificity of catalyst, promoters and the development of high-pressure technique.
10. Langmuir, Taylor, and others. Study of catalytic action as related to our modern interpretation of the structure of matter.

HIGH PRESSURE BOMB (ROTATING) IPATIEFF TYPE

The study of catalytic reactions started with *hydrogenation*. There are several reasons for this choice: (1) industrial importance of the reaction; (2) its highly developed technic; (3) variety of catalyst preparation methods; (4) varying activity of these catalysts, dependent on the preparation method. In discussing hydrogenation, as well as the subsequent reactions in this course, the following scheme was adhered to:

1. Definition of terms.
2. Discussion of general chemistry of the reaction.
3. Description of apparatus and procedure used.
4. Preparation of catalysts and their properties.
5. Use of the method.
6. Mechanism and theories of the reaction.
7. Brief discussion of the industrial applications.

ALUMINUM HIGH PRESSURE BOMB FOR WORK AT ROOM TEMPERATURES

In presenting hydrogenation to the class, hydrogenation proper, hydrogenolysis (destructive hydrogenation), and selective hydrogenation were defined and illustrated. Three methods were discussed:

1. Sabatier's vapor phase method at high temperature and atmospheric pressure.
2. Ipatieff's high temperature, superatmospheric pressure method in vapor, liquid and solid phase.
3. The Paal-Skita-Adams colloidal catalyst method at low (room) temperature and atmospheric pressure.

Discussion of these methods was supplemented by laboratory work. Students hydrogenated benzene by the Sabatier vapor phase and the Ipatieff high-pressure methods. In this first work, the importance of catalyst activity and its dependence on the method of preparation were clearly illustrated. Students prepared two nickel catalysts, one by the impregnation-ignition method (nickel-asbestos) and two by a precipitation method. Whereas the latter hydrogenates benzene at atmospheric pressure, the former requires superatmospheric pressure to accomplish the same reaction. The topic of selective hydrogenation was presented in the light of the recent studies by Adkins, Ipatieff, and an M. I. T. group (Thompson, *et al.*). The incompleteness of information on this important subject and the necessity of future research work were emphasized. In discussing the mechanism of catalytic hydrogenation the classical theories of Sabatier (hydrides) and Ipatieff (water) were presented. These theories were supplemented by Schmidt's theory of the subject (ions), and by the work of petroleum chemists, such as Twigg, Beeck, and others. The topic of hydrogenation was concluded by discussing the following industrial processes.

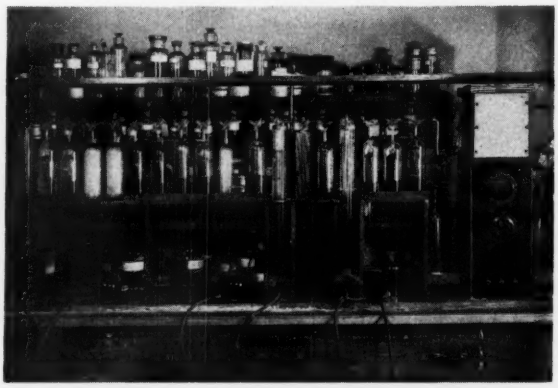
1. Hydrogenation of vegetable oils.
2. Hydrogenation of selective polymers (iso-octane production).
3. Destructive hydrogenation of petroleum products.
4. Liquefaction of coal (Bergius Process).
5. Hydrogenation of carbon monoxide and dioxide (Fischer-Tropsch Process).

DEHYDROGENATION

Dehydrogenation has acquired prime importance during the last few years. Study of this reaction was conducted along the following topics:

1. Dehydrogenation of alcohols to aldehydes and ketones.
2. Dehydrogenation of alicyclic compounds.
3. Dehydrogenation of aliphatic hydrocarbons to olefins and diolefins.
4. Dehydrocyclization of aliphatic hydrocarbons with chain length of six or more carbon atoms (Toluene Production).

In discussing dehydrogenations of alicyclic compounds, the classical and extensive work of Zelinsky's school was studied with particular care. Also included were the six-membered carbon ring rule of Zelinsky, the Balandin multiplet theory, the behavior of the five-carbon ring compounds, the phenomena of irreversible catalysis. The x-ray and electron ray investigations of Germer, Rupp, Rubinstein were presented to the students. The topics of hydrogenation and dehydrogena-



GOECKEL ADSORPTION APPARATUS FOR ANALYSIS OF GASES

tion were concluded with discussions of inter- and intramolecular dehydrogenation-hydrogenation using acidic catalysts such as sulfuric or phosphoric acids, aluminum chloride, etc. Laboratory work included:

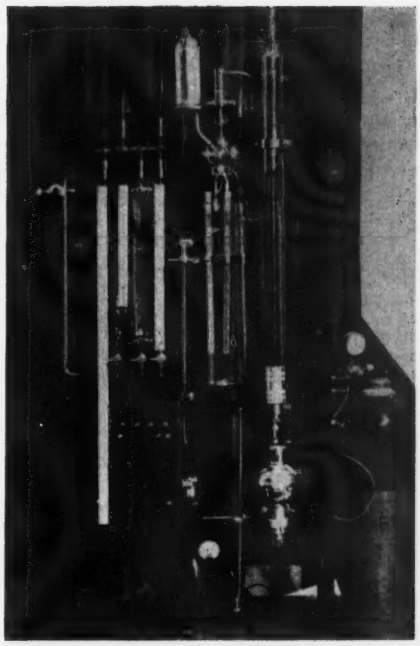
1. Dehydrogenation of alcohol to aldehyde using zinc oxide and copper oxide catalysts.
2. Dehydrogenation of cyclohexane over co-precipitated nickel-alumina catalyst.

In the last case methods of reactivating the catalyst were discussed and carried out. The industrial dehydrogenations discussed were:

1. Dehydrogenation of gaseous alkanes to olefines (aviation gasoline).
2. Dehydrogenation of olefins to diolefins (synthetic rubber).
3. Catalytic reforming of gasoline.

DEHYDRATION

The following reactions were presented under the topic of dehydration: the reaction of Williamson, dehydration of alcohols to olefins in liquid and in vapor phase, the dehydration of acids, esters, acid amides and aldoximes, simultaneous dehydration, hydrogenation, and dehydrogenation, complex action catalyst, catalysts for dehydration and conditions of the experiments. The laboratory work consisted in preparation of an alumina catalyst by the precipitation method and comparison of its activity with a commercial alumina catalyst in the reaction of dehydration of ethyl alcohol. The chapter was concluded by the discussion of the hypotheses of Taylor, Ipatieff, and Adaduroff as well as experiments of Adkins on the mechanism of dehydration reactions.



HIGH EFFICIENCY FRACTIONATION COLUMN (FOR LIQUIDS)—PODBIELNIAK

HYDRATION

The production of alcohols from olefins, the saponification of esters, the inversion of sugar, and the hydration of acetylenes were presented in this chapter.

CONDENSATION

The definition of the reaction. Condensation of alcohols with aldehydes and ketones. Condensation of phenols with alcohols, aldehydes, and ammonia. Various condensations with aluminum chloride catalyst. The laboratory work consisted of the preparation of pure aluminum chloride catalyst and the performance of the Friedel-Crafts reaction.

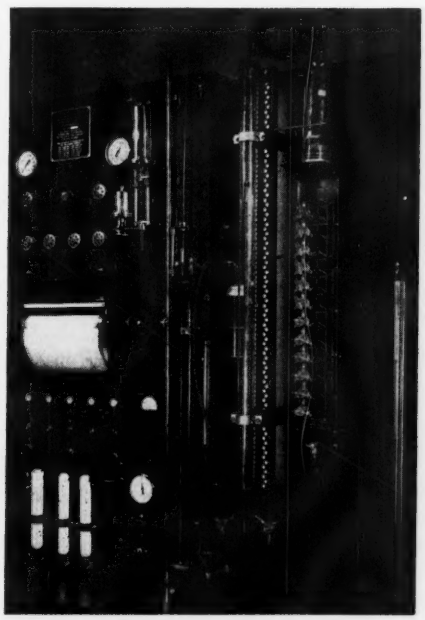
ISOMERIZATION

The following reactions were studied: displacement of double and triple bonds, change of the ring structure, change of the chain structure, *cis-trans* isomerization, metameric isomerization of ethylene oxides.

The industrial application of isomerization reactions was illustrated by isomerization of normal butane to iso-butane in the presence of aluminum chloride catalyst.

POLYMERIZATION

The definition of the term "polymerization." The organic groups which undergo the polymerization reaction. The following reactions were discussed: polymerization of aldehydes, sugars (work of Pictet), nitriles, unsaturated hydrocarbons. The formation of



AUTOMATIC FRACTIONATION COLUMN FOR GASES (HYDROBOT)—PODBIELNIAK

natural polymers, synthetic rubber production. The laboratory work consisted in high-pressure polymerization of propene in the presence of phosphoric acid catalyst. The mechanisms of Ipatieff, Berthelot, Monroe, and Gilliland and Whitmore were discussed in connection with this experiment. The reactions of cross polymerization, selective polymerization, hydro- and dehydropolymerization, and conjunct polymerization were defined and illustrated. The following industrial processes were presented at the conclusion of this chapter, both of which lead to the production of high octane motor fuel:

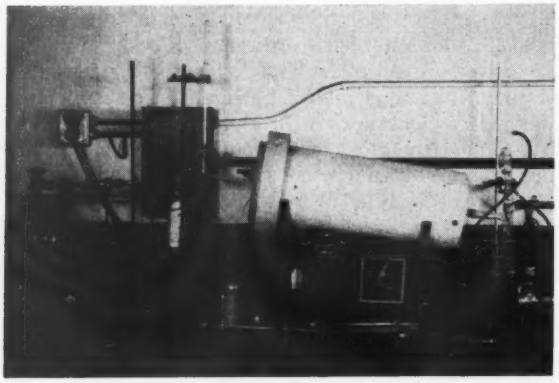
1. Universal Oil Products Company polymerization of olefins in the presence of solid phosphoric acid catalyst.
2. Shell Oil Company polymerization of butenes in the presence of sulfuric acid catalyst.

ALKYLATION

The definition of reactions of alkylation: direct alkylation, alkylation by condensation, destructive alkylation and autodestructive alkylation. Alkylation of aromatic, alicyclic and paraffin hydrocarbons, alkylation of phenols. Catalysts and conditions used. Mechanism and theories. Laboratory work included:

1. The alkylation of benzene with ethylene in the presence of aluminum chloride.
2. The alkylation of benzene with propylene in the presence of sulfuric acid.
3. The alkylation of phenol with iso-butene in the presence of phosphoric acid.

The industrial application of the reaction was illustrated by the sulfuric acid alkylation process for the production of aviation fuel.



HORIZONTAL, ELECTRICALLY HEATED, CATALYTIC FURNACE WITH AUTOMATIC TEMPERATURE CONTROL

OXIDATION

The following types were discussed: oxidation of carbon monoxide by oxygen and by water, oxidation of paraffin hydrocarbons, oxidation of methane to formaldehyde, oxidation of methane to carbon monoxide and hydrogen, oxidation of higher paraffins to acids, oxidation of alcohols (methyl, ethyl, and isopropyl), oxidation of aromatic compounds (benzene, naphthalene), methods of the Barrett, Monsanto, and Dow Chemical Companies.

ADDITION AND ELIMINATION OF HALOGEN, NITROGEN, AND SULFUR-CONTAINING GROUPS

The last few lectures were devoted to the physicochemical study of catalytic reactions. These studies were divided into three groups.

1. Adsorption and its role in catalytic reactions. Various types of adsorption. Capillary condensation. Faust rule. Heats of adsorption. True adsorption, its importance in catalytic reaction. Langmuir's work, monomolecular layer. Variety of the phenomena on the surface of a catalyst.
2. Kinetic studies of catalytic reactions. Intermediate compound formation. Energy of activation. Elucidation of reaction mechanism from kinetic measurements.
3. Studies of catalytic phenomena from the point of matter structure. Activation of the surface. Poisoning of the surface, active centers, mixed catalyst. Role of carriers and promoters. The geometry of catalytic surface. Catalytic activity and particle size. Orientation of crystals. General conclusions.

BOOKS

Although various selected chapters of the following books[2] were recommended to students in the presentation of this course, the major part of the studies must be based on the original literature.

General:

1. SABATIER, "Catalysis in organic chemistry," Van Nostrand, New York, **1923.**
2. RIDEAL AND TAYLOR, "Catalysis in theory and practice," Macmillan and Company, London, **1926.**
3. IPATIEFF, "Catalytic reactions at high pressures and temperatures," The Macmillan Company, New York, **1936.**
4. BERKMAN, MORREL, AND EGLOFF, "Catalysis, inorganic and organic," Reinhold Publishing Company, New York, **1940.**

Hydrogenation:

5. MAXTED, "Catalytic hydrogenation and reduction," London, **1919.**
6. ELLIS, "Hydrogenation of organic substances," Van Nostrand, New York, **1930.**
7. ADKINS, "Reactions of hydrogen," The University of Wisconsin Press, Madison, Wisconsin, **1937.**

Dehydrogenation and Oxidation:

8. MAREK, "The catalytic oxidation of organic compounds in vapor phase," Chemical Catalog Company, New York, **1932.**

Polymerization:

9. BURK, THOMSON, WEITHAND, WILLIAMS, "Polymerization and its application in the field of rubber, synthetic resins, and petroleum," Reinhold Publishing Company, New York, **1937.**

Isomerization:

10. EGLOFF, HULLA, AND KOMAREWSKY, "Isomerization of pure hydrocarbons," Reinhold Publishing Company, New York, **1942.**

Alkylation, Condensation and Other Reactions:

11. THOMAS, "Anhydrous aluminum chloride," Reinhold Publishing Company, New York, **1941.**

[2] Only books in the English language are presented in this list.

Theory and Mechanism:

12. SCHWAB, "Catalysis from the standpoint of chemical kinetics," Van Nostrand, New York, 1937.
13. NYROP, "The catalytic action of surfaces," Williams and Norgate, Ltd., London, 1937.
14. GRIFFITHS, "The mechanism of contact catalysis," Oxford University Press, Cambridge, 1936.
15. BELL, "Acid-Base catalysis," Oxford Clarendon Press, Cambridge, 1941.

Industrial Applications of Catalysis:

16. GREEN, "Industrial catalysis," E Benn., Ltd., London 1928.
17. HENDERSON, "Catalysis in industrial chemistry," Longmans Green and Co., London, 1919.
18. HILDICH, "Catalytic processes in applied chemistry," Chapman and Hall, Ltd., London, 1937.
19. *See also* "The twelfth report of the committee on catalysis, National Research Council," Wiley and Sons, New York, 1940.

Nicolas Leblanc (1742–1806)

RALPH E. OESPER, ***University of Cincinnati, Cincinnati, Ohio***

IT MAY indeed be averred, without fear of contradiction, that since the first application of chemical science to manufacturing operations, few discoveries have been made having such an important bearing whether considered in relation to social life, to commerce, or to the progress and successful prosecution of the useful arts, as that of the production of carbonate of soda from common salt. It would indeed be difficult to exaggerate the importance of this manufacture." This statement, penned by the great English chemical manufacturer Muspratt about 1850, was echoed, nearly a century later (1937) by a writer in *Fortune Magazine*. In his article, "Chemical Industry," he declares: "The man who began it was the Frenchman Nicolas Leblanc, and the year of his achievement was 1791. Leblanc was not trying to make history. He was just trying to make a little money."

This excellent popular account of the significance of Leblanc's achievement will suffice for the general public, but those who take a serious interest in the history of chemistry will not be satisfied by this flowing but cursory review. What is needed is a fairly detailed account of Leblanc's life, the genesis of his process, its development to a commercial scale, the effect of the Revolution on his business, his increasing efforts to obtain indemnities, and his tragic end. This interesting story has never been told *in extenso* for the English-reading chemical world, and a golden opportunity to do so is offered by the 200th anniversary of Leblanc's birth.

Nicolas Leblanc was born on December 6, 1742, at Ivoy le Pré, a small town in the present Departement du Cher. His father, a minor official in an iron works, died in 1751, and Nicolas was sent to Bourges. Here he was under the watchful eye and influence of his father's good friend, Dr. Bien. From him Leblanc absorbed an interest in medicine, and when the good man died in 1759 Nicolas, only seventeen, went to Paris to study medicine and surgery. He enrolled at the École de Chirurgie; in due time he emerged as Master of Surgery and began to practice his profession.

Chemistry was beginning to gain more importance. The teaching in this subject was confined almost entirely to lectures, and these were given mostly by medical men. Consequently it was a great event when in 1770 the Chair of Medicine at the Collège de France was transformed into a Chair of Chemistry. Jean Darcet (d'Arcet) became professor here in 1775. He was granted the right to lecture in French, contrary to the general custom of using Latin for this purpose, and he also discarded another tradition when he taught without donning academic robes. Darcet was a real chemist; he distinguished himself by the technical improvements he developed at the Sevres porcelain works, at the Gobelin tapestry studios, and at the Mint. He was also a successful teacher and his lectures drew large audiences who were anxious to hear a man of this caliber expound chemistry.

Serious medical men at this time were interested in chemistry and flocked to Darcet's lectures. Among these was Leblanc, by now (circa 1785) far beyond the normal student age. He met here such men as Berthollet, Vauquelin, Fourcroy, Haüy, who became his lifelong friends. It is interesting to note how many of the leading French chemists began as physicians.

In 1775 Leblanc married; the first child was born in 1779. Leblanc's patrimony had been consumed by his schooling, and as his family responsibilities increased he needed a more regular income than was provided by the fees from his private patients. In 1780 he accepted the post as physician to the household of the Duc d'-Orleans (1747–1793).

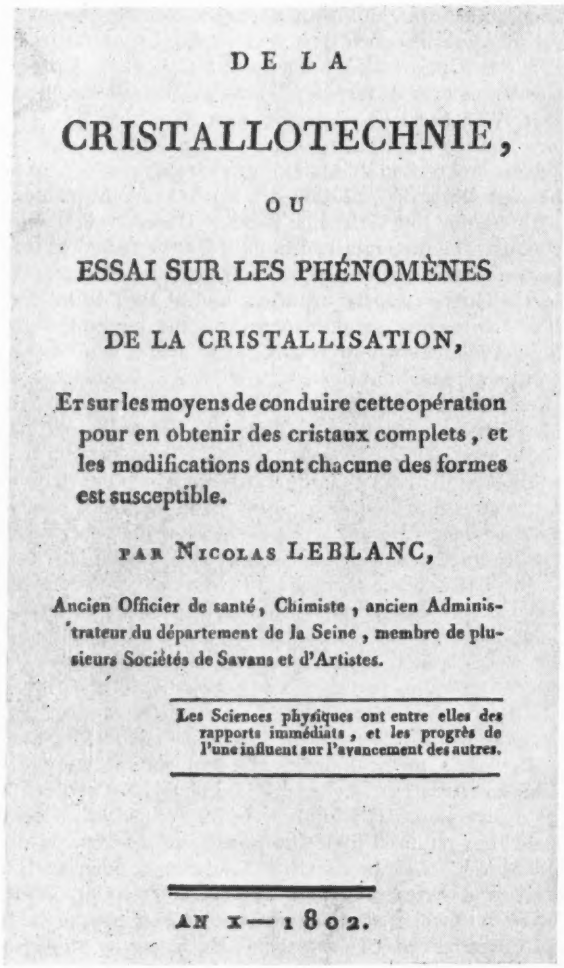
Leblanc's medical duties did not fully occupy his time or attention; he turned to chemical experiments as a diversion. His funds were limited, so he chose a field that required little equipment and few chemicals. In March, 1786, he sent the Academy of Sciences the first of a series of papers on crystal growth. These were so excellent that the reviewing committee, in July, 1792, recommended

"that the Academy invite M. Leblanc to consider the formation of a complete collection of all crystallized salts—that the execution of this project be given special support because he has already spent considerable time on it and has made sacrifices, which

his limited means render all the more valuable. It would be desirable to put M. Leblanc's collection in a place where it might serve for the instruction of those who are studying natural history, particularly crystallography. It is to be hoped that the author will hasten to publish the various papers he has written on this subject to guide those who wish to take up the practice of an art that is new in many respects, that is of interest for the progress of chemistry, and which may even serve as a source of enlightenment in perfecting the theory of crystallization."

The Academy was abolished before the recommendation could be put into effect, but the Committee of Public Instruction, in June, 1794, requested Leblanc to continue this work. However, the events of the Revolution interfered. In 1802 the Institut successfully recommended that public funds be provided to publish his "De la Cristallotechnie."

Darcet was interested in the production of pure nickel, and at his suggestion Leblanc studied this problem. The inconclusive results were not published until twelve years later (1798). The spontaneous combustion of piles of coal and methods of preventing such fires were discussed in a paper read to the Athenée des Arts in 1788. His unpublished "Comparative analyses of French and English coals" are of this same date. These unimportant papers are significant because they reveal that Leblanc's mind was constantly busy with the application of chemistry to industrial problems.



DE LA

CRISTALLOTECHNIE,

OU

ESSAI SUR LES PHÉNOMÈNES

DE LA CRISTALLISATION,

Et sur les moyens de conduire cette opération pour en obtenir des cristaux complets, et les modifications dont chacune des formes est susceptible.

PAR NICOLAS LEBLANC,

Ancien Officier de santé, Chimiste, ancien Administrateur du département de la Seine, membre de plusieurs Sociétés de Savans et d'Artistes.

Les Sciences physiques ont entre elles des rapports immédiats, et les progrès de l'une influent sur l'avancement des autres.

AN X — 1802.

TITLE PAGE OF LEBLANC'S ONLY PUBLISHED VOLUME
This has become quite rare. A copy is in the Chemistry Library of the University of Cincinnati.

Potassium carbonate was by far the more important of the two fixed alkalies up to the time of the French Revolution. The chief source was wood ashes, and the price rose steadily as the available forests receded from the industrial countries of western Europe. Russia, Scandinavia, and North America were far away and shipping costs were high. A cheaper alkali was imperative if the growing glass, textile, and soap industries were not to be throttled, and it obviously was to be sought in the base of sea salt. Most of the sodium carbonate used in France was imported from Spain and the French paid a "tribute" of 20 to 30 millions livres annually to the "foreigner."

Methods of preparing soda from salt on an industrial scale were in operation, but the results were not good enough. In 1783, Louis XVI ordered the Academy to offer a prize for the best solution of the problem: "To discover the simplest and most economical method of decomposing sea salt on a large scale, in order to secure from it the alkali that serves as its base in a state of purity uncombined with acid or other material; the cost of this mineral alkali not to exceed the price at which it can be extracted from the better foreign sodas." The price, 2400 livres (about $2400 in 1940 buying power) was offered each year until 1788. It was never awarded; the Academy had ceased to exist before Leblanc's process was developed.

In 1778, Father Malherbe, a Benedictine monk, heated sodium sulfate with iron and charcoal, and extracted soda from the cooled residue. A factory using this process operated for a time. Higgins, in 1781, took out a patent in England for a similar method: sodium sulfate was melted with charcoal and then iron or lead was added. Guyton de Morveau and Carny, in 1782, used a process discovered by Scheele in 1775. A moistened mixture of salt and lime was exposed to the air; after some time an efflorescence of soda appeared on the surface. Athenas converted salt into sodium sulfate, first by means of copperas (ferrous sulfate), afterward by roasting with pyrites or pyritiferous lignite. The sulfate was converted to soda by Malherbe's method. None of these processes could successfully compete with Spanish barilla, either in quality or price.

Lametherie (De la Métherie), who for many years edited the *Journal de physique*, in 1789 published a proposal that manifestly was not the fruit of actual experiments. Sodium sulfate and charcoal, heated together in a retort, were reported to produce sodium carbonate and sulfur dioxide. The gas was to be made again into sulfuric acid, to be used for producing more sodium sulfate. "Undoubtedly this would be an extremely beautiful process if the reactions took place in

the way imagined by De la Métherie, but unfortunately on igniting sodium sulfate with coal, much sulfide and little carbonate are formed." Lametherie knew that this might "partially" occur. He suggested, therefore, that any sulfide (and, of course, along with it the carbonate) be decomposed by adding acetic or another organic acid, and the resulting organic salt was then to be converted to carbonate by ignition. "But these vegetable acids will be expensive" warned the author of this impractical scheme.

Leblanc began to work on the "soda problem" about 1884, doubtless impelled by the hope of securing the Academy prize. He started in a sensible way:

"I found, in general, that the known methods were incomplete, inadequate or too expensive. . . . The citizen Lametherie published in the *Journal de physique* some observations on the decomposition of the sulfate of soda by incineration with coal; he does not doubt that additional experiments will provide some day the method of completely decomposing the sulfate, known as Glauber's salt. I pursued this idea, and the addition of carbonate of lime fulfilled my object perfectly. In this, I anticipated Lametherie; it was to his observations that I owed this first success, since they occasioned my final experiments."

It is unfortunate that Leblanc left no account of the history of this discovery. The Duc d'Orleans was interested in industrial investments; he had put money into a sugar factory at Bercy, and into a cotton mill at Orleans. Consequently when Leblanc thought that his results were sufficiently promising to warrant full-time investigation, he met with a favorable reception when he asked his employer to finance his experiments. Darcet had been consultant to the Duc[1] on other technical matters, and it was stipulated that Darcet was to certify the merits of any soda process developed by Leblanc before the Duc would invest in its commercial application.

Leblanc was given laboratory space at the Collège de France. Darcet, who was fully occupied, asked his assistant to work with Leblanc. This was a strange combination: Dizé (b. 1764), a trained, professional chemist in his twenties; Leblanc, physician, amateur chemist, twice the age of his appointed collaborator. Dizé published an account of their labors, but the internal evidence of his statements testifies that his recital was not in accord with the facts. He sought to give the impression that Leblanc was capable of nothing more than blind fumbling. Dizé's claim that he was entitled to the lion's share of the glory, that he provided the skill and ideas, has been accepted by very few, and no one now seriously maintains that the Leblanc process should rightfully have been called the Dizé or even the Leblanc-Dizé process. Dizé's claim did not appear until after Leblanc's death, and this timing in itself prejudices Dizé's case.

[1] During the Terror, Robespierre placed Darcet on the list of proscribed because of his intimacy with the Duc d'Orleans. Strenuous efforts by Fourcroy were all that saved Darcet from the guillotine; he showed that the relations antedated the Revolution by many years. When the Duc was arrested he was imprisoned near Marseilles. Dizé tried to collect a fund to bribe the jailer but older heads convinced him that the scheme was too dangerous.

The crux of the process is the inclusion of calcium carbonate in the fusion mixture. The steps which led to this fortunate discovery are not recorded. It is reported that it grew out of an analytical procedure.

Jean d'Arcet, Professor of Chemistry at the Collège de France.
Engraving in the possession of the National Library, Vienna.

JEAN DARCET (1725–1801)

Leblanc, in a letter to Darcet, wrote: "I will always be proud to state that I am indebted to you for most of the knowledge I have gained in chemistry, and it was your advice that fundamentally directed my work."

Trials of Lametherie's proposal were checked by acidifying samples and allowing the hydrogen sulfide to react with lead nitrate. It was found that carbon dioxide would also release the hydrogen sulfide and the residue then contained carbonate. As the carbon dioxide had been obtained from limestone, attempts were made to use the latter directly; calcium carbonate was boiled with sodium sulfide solution. Nothing much happened, so more drastic measures were tried. A mixture of limestone and coal was moistened with sodium sulfide solution, the paste was dried and partially fused in an iron pot. The water extract of the fusion residue was found to contain much less sulfide than any product they had ever obtained. Darcet, who was kept informed of the findings, advised them to use a crucible and to fuse the mixture completely. Within a few hours, the first batch of soda crystals was isolated. The next step was obvious: sulfate, coal,

and limestone were fused together. The essential victory was won. The exact date is not known; in all likelihood it was late in 1789, and probably came three or four months after Leblanc began his work at the Collège de France.

The time had come for further discussions with the Duc d'Orleans. He had been sent out of France in October, 1789, because Lafayette feared his political activities, and did not return until July, 1790. Leblanc and Dizé went to London. After the necessary conferences, a preliminary agreement was signed by them and the Duc's steward, Henri Shee (1739–1820), on February 12, 1790. The terms of this agreement were not made public until 1856. The essential points were: (1) Leblanc was to deposit a complete description of his process for making soda; (2) Dizé to do likewise for his method of manufacturing white lead; (3) details of a sal ammoniac manufacture were to be given by Leblanc, who made no claims that the method was original; (4) the descriptions of the soda and white lead processes were to be certified by Darcet, and then sealed by the three principals, and not be opened except in case of death, or abandonment by the authors. In return, the Duc engaged to furnish 200,000 livres to enable Leblanc and Dizé "to carry on the said processes advantageously." It is important to note that Dizé is not mentioned in connection with the soda process. The detailed procedures, together with Darcet's certificate (notarized on March 24, 1790) were deposited at Paris on March 27, 1790, with the notary Brichard. These documents also remained sealed until 1856. They were then opened by court order at the request of the Academy of Sciences.

The inevitable delay in bringing the process out of the laboratory stage into commercial practice required about a year. A site was chosen, buildings erected, machinery and equipment assembled. Leblanc and Dizé signed a private agreement on January 15, 1791. The profits from soda and sal ammoniac were to be divided three-fifths to Leblanc, two-fifths to Dizé; the gain from the white lead (actually sulfate) was to be distributed in the reverse proportion. The right of each to his own invention was reaffirmed. The sal ammoniac manufacture was a natural appendage to the soda process. It made use of the hydrogen chloride obtained in the preparation of salt cake; the ammonia was obtained by distillation of animal materials.

On January 27, 1791, Leblanc, Dizé, and the Duc d'Orleans entered into a definite partnership. Shee was to be recognized as the administrator of the Duc's interests. Leblanc's salary was fixed at 4000 livres per year, Dizé was to receive 2000 livres. These were minimum payments, and were guaranteed in case their shares of the profits did not reach these amounts. The first tenth of the net return was assigned to the Duc, as interest at 4% and to amortize his capital payment of 200,000 livres. Any remaining profits were to go: nine-twentieths to the Duc, six-twentieths to Leblanc, three-twentieths to Dizé, two-twentieths to Shee. The possibilities of really big returns had not escaped the partners, because a different formula was set up for the apportioning of any profits above one million livres earned in any year. If the process was a success, the Duc planned to set up a soda factory, with a capital of 1,000,000 livres, on his salt marshes near Marseilles.

In 1791, the Constituent Assembly granted inventors the right to secure patents. Leblanc applied, and Darcet, Desmarest (geologist, Inspector of Industries), and Servieres (Director of Patents) were appointed to verify the accuracy of the description of the process. Their report stated:

> "We, together with the said M. Leblanc, went to his manufactory . . . where this skilled chemist showed us in great detail the buildings, furnaces, etc. . . . constructed for the large-scale application of his methods and processes, whose products he showed to us, and whose underlying chemical theory he expounded, and which we have found to be based on the best principles. . . . . Having carefully examined the method employed by the said M. Leblanc for producing soda by the large-scale decomposition of sea salt, we acknowledge that the invention is new and very superior to all that up to now have come to our knowledge as regards to economy, speed and certainty of the method as well as regards to the abundance and purity of the products. . . . . We believe that the discovery of M. Leblanc for political and economic reasons merits the encouragement of the French nation, and that the secret of his discovery should be well guarded."

A patent was granted on September 25, 1791; the fee was 1500 livres. This was a secret patent, which meant that no public disclosure was necessary. Leblanc thus secured the exclusive right to work or licence his process for a period of fifteen years. Dizé, at the time, made no objection; many years later he declared that Leblanc applied for and secured the patent entirely without the sanction or knowledge of his partner.

The description of the process deposited by Leblanc in 1790 called for sodium sulfate 100 parts, limestone 50 parts, coal 25 parts. The patent specified 100, 100, 50. "The proportions of the raw materials may be changed, but the foregoing have given the best results." During the many years of the large-scale application of the process these figures were altered only to 100 : 100 : 35.5. The patent also recommended the use of a reverberatory furnace in place of crucibles. Substantially all the improvements that were subsequently made were along the line of mechanical equipment. "Rarely has there ever been a process so nearly perfect in form as that first discovery by Leblanc."

The soda works was built at St. Denis, a small town four miles from Paris. It was called "La maison de Seine," and over the entrance was a sign, "Fabrique de Soude de N. Leblanc." The beginnings were propitious; every day 500 to 600 pounds of soda were produced, also some lead sulfate and ammonium chloride. Because of the war with Spain, the price of barilla had gone up enormously, and consequently there was a large profit in the manufacture of soda from common salt. It is reported that by the spring of 1794, the soda sale had totalled 420,000 livres, of which 112,000 livres was clear profit, not counting the return from the other products.

Ever since the invention of gunpowder, warfare has been increasingly dependent on the chemical industries. Supplies of potassium nitrate were short and the French leaders were making every effort to meet the essential needs. It was made mostly by treating calcium nitrate, extracted from niter-bearing earth, with potassium carbonate. Consequently any material that would conserve potash was of prime importance to the national welfare. The Committee of Public Safety, which was essentially an executive war cabinet, set up a Commission of Powder and Arms to deal specifically with questions relating to munitions. Guyton de Morveau, the eminent Dijon chemist, was the leading member of this commission. "To chemists, as such, the Committee of Public Safety gave a warm welcome. No government had ever before made such an attempt to associate itself with science."

Guyton de Morveau wrote to all the soda manufacturers on January 27, 1794.

"Citizen: The Committee of Public Safety is now concerned with securing a large-scale production of soda. It desires to collect all the knowledge possessed by those who have worked on this commodity, particularly on its production from common salt. I know that you have been in a position to contribute to the formation of this new art, whose product will free potash for the manufacture of saltpeter. Accordingly I request that you present yourself to this Commission, to confer on this topic."

The *Moniteur* carried the following notice on January 31, 1794:

"The Committee of Public Safety of the National Convention to its fellow-citizens: The Republic needs potash for the manufacture of saltpeter, and soda would replace potash in some of its uses. Nature has provided us with boundless quantities of common salt from which soda can be made. Consequently the execution of this operation on a large scale has now become a matter of public safety. The accomplishment of this end is no longer a matter of simply announcing a discovery, or of seeking judgment on some small-scale experiments with a view to securing exclusive rights to them by the grant of a patent. The interests of the individual cease to exist when they are placed over against the public interest. It is generally known that numerous ventures have not yet succeeded in cutting down the importation of foreign sodas; it is now quite clear that even the better organized factories, if left to their own resources, will furnish no more than far-distant hopes and will be useless to meet the present need. One course of action remains, it will surmount all obstacles because it will bear the imprint of the Revolution. Let there be brought together all the enlightenment provided by theory and obtained from experiments, and soon, by comparing and pooling all this information, under the present favorable conditions and in view of the high price that these have brought to this industrial product, we shall witness the creation of a new art, destined at first to contribute to the defence of liberty, and in the course of time to free us from a commercial dependence. With these thoughts in mind, the Committee of Public Safety invites all citizens who have made some trials, who have collected some observations on this subject, to communicate them to the Commission which it has established to receive them, and which is charged to analyze them and to report its conclusions.

"The Committee cannot pass over in silence the fact that its desire has been anticipated by several citizens, who, guided by the same reflections, have come forward and offered the detailed description of the processes for which they have obtained patents and established factories. Doubtless others will be eager to follow this example. A true republican does not hesitate to relinquish the ownership of even the fruits of his mind when he hears the voice of his country entreating for aid."

The volunteers were Carny and Guyton de Morveau, whose soda works in Picardy had not been profitable, so their sacrifice was little more than a gesture.

Barère, spokesman for the Committee of Public Safety, on February 1, 1794, declaimed to the National Convention:

"A new art has been born of modern chemistry, whose revolution preceded the revolution of liberty; a new chemical art, namely the production of soda from common salt, thus multiplying on our territory a commodity that the foreigner now sends us, and which we shall soon send to the foreigner. This is going to save potash and replace it in all its uses, so that it may be sent back to the manufacture of saltpeter.... Citizens! Matters related to the common defence are no trifling matter. The right to requisition and to seize are indispensable to the Commission of Powder and Arms. Does any citizen, any proprietor, any manipulator have the right to hold back, to hoard, to conceal any materials essential to the manufacture of arms and powder? What man has the right to fetter the zeal of the defenders of the nation and to set limits to its means of defence? All Frenchmen are now soldiers! When the need is here private fortunes become the public fortune; possessions cease to be individual, they become the property of all."

The Commission was given broad powers over all materials related to the production of munitions; those who opposed such measures were to be regarded as suspects and dealt with accordingly. It was decreed: "All citizens, who have established factories or who obtained patents for inventions to make soda from salt, are hereby ordered, even though they are planning to enlarge these establishments as much as possible, to make known to the Commission, within two decades (20 days), the location of these plants, the quantity of soda they put on the market, how much they can furnish, and the date at which they can start their deliveries."

The soda manufacturers thus found themselves the object of considerable attention. For Leblanc and his associates the picture was darkened and materially confused by the fact that their backer, the Duc d'Orleans, known during the Revolution as Philippe Egalité, had been guillotined on November 6, 1793. His property was confiscated to the State; in other words, the soda factory now belonged almost entirely to the government. The officials proceeded on the basis that they, and not Leblanc and his partners, were in charge. It was under these circumstances that the business was carried on from October, 1793, to February, 1794.

Leblanc was in Paris when he received the following letter from Shee. It was written on February 1, 1794.

"I have just read in yesterday's *Moniteur* that all republicans, who hold any secrets or processes for the manufacture of soda from common salt, are invited to disclose these to the Committee of Public Safety, because the Nation may secure from them valuable advantages for its defence. I suppose that you are quite well aware of this matter, and I am sure that your patriotism immediately will prompt you to sacrifice your secret, the fruit of your long and arduous researches.

"Nevertheless, believing that your sense of delicacy may evoke some scruples regarding the soda manufacture, I am hastening to assure you that I, with all my heart, give my consent, and even urge you, if there be need of it, to reveal to the Nation all that you know about this important subject. I am convinced that citizen Dizé will find in his civism the motives necessary to ap-

prove this step; besides you are in a position to discuss this with him. As regards my personal interest, I entrust myself wholly to the dictates of your prudence and probity.

"I sincerely trust that your secret may have the glory of contributing in a large and effective manner to the safety of our country. *P. S.* Your letter of the 6th did not reach me until the evening of the eighth. That very evening the citizens de Flandre, La Treille, and one other came to the factory in the name of the district and municipality of Franciade [the revolutionary name of St. Denis] and made a general inventory of everything. I can no longer dispose of the slightest item without a legal order."

(*To be continued in January*)

What's Been Going On

PURE NITROGEN instead of water is what was obtained when a well was sunk 156 feet on a ranch in eastern Wyoming. The well has been capped for use in the war emergency program.

Dr. Bridgman, of Harvard University, has produced ice at 375°F. (water boils at 212°F.) under a pressure of 40,000 atmospheres, which is the approximate pressure 1000 miles below the surface of the earth.

Reports from Italy indicate that grapeseed oil is being introduced as a substitute for linseed oil.

Methane, compressed under 300 atmospheres, is being used on what is believed to be the first methane gas fed railway engine. It is 120 horsepower, and operates on the route from Rovigo to Chioggia (Venice).

The production of the gunpowder required to fire a rifle bullet requires about two ounces of alcohol.

d–Ribose, formerly valued at $18,000 a pound, may be obtained in unlimited amounts from the liquor waste of American paper mills, according to Dr. Jonas Camlet of Miles Laboratories.

According to G. J. Martin, and C. V. Fisher of the Werner Institute for Therapeutic Research, *p*-aminobenzoic acid (0.5 g. per kilo of body weight) completely inhibits the protective action of sulfanilamide (2.0 g. per kilo) against an induced streptococcus infection.

Rubber requirements that must be met: 150,000 pounds for a 35,000-ton battleship, 3200 pounds for a 10-ton pontoon bridge, 1750 pounds for a medium tank, 1250 pounds for a flying fortress, 125 pounds for a half-ton truck, and 1.8 pounds for a gas mask.

Sweden now has a shale oil production of about 30,000 tons a year.

Rumania is constructing a plant for the production of 3000 tons of synthetic rubber annually. This will be of the Buna type, and will be produced from natural gas.

Studies during the past summer definitely indicate that the use of two vitamin C tablets daily is an effective way to "beat the heat."

Ethide, 1,1-dichloro-1-nitroethane, has been used satisfactorily at the University of New Hampshire as an insecticide for the protection of grain, flour, fabrics, and furs. It appears to be non-injurious to human beings.

The conversion of ethyl alcohol to butadiene, in a single-stage operation, was first effected in 1903 on a laboratory scale by Professor Vladimir N. Ipatieff, now with Universal Oil Products Co.

Forty million Americans, according to Surgeon General Thomas Parran, are suffering from vitamin deficiency.

The United States Rubber Company announce that the processing cycle in the reclamation of rubber has been reduced from 16 hours to 9.5 hours, with an improvement in the quality of the finished reclaim. Leather is being replaced in part of Germany by paper fleece impregnated with synthetic resins.

A gum resin, presumably produced from tomato skin, is replacing linseed oil in the production of linoleum in Italy.

Fiberglas is assuming increasing importance in replacing such materials as aluminum, cork, mica, and non-ferrous asbestos.

Of the 1,387,926 tons of crude rubber marketed in 1940, 1,246,100 tons were produced by countries now dominated by the Axis.

According to Egloff and Van Arsdell, the Americas produce 78.27% of the crude oil of the world; Europe, 13.13%; Asia, 5.04%; Oceania, 3.19%; and Africa and the rest of the world, 0.37%. Of the 295 million barrels produced annually in Europe, Russia produces about 240 million barrels. The production of synthetic gasolines in Germany and German-controlled countries is estimated at about 65 million barrels.

Sulfadiazine ointment is very effective in the treatment of burns, and is being used extensively in the armed forces.

Plastic lenses to fit every pair of eyes in the service is the objective back of the production of nine thousand different molds for plastic lenses.

Forty thousand barns could be painted annually by the lipstick used by American women.[1]

ED. F. DEGERING

[1] (But who wants to kiss a barn?)

Symposium on the Teaching and Practice of Analytical Chemistry

INTRODUCTORY REMARKS

F. E. BROWN

Iowa State College, Ames, Iowa

A RECENT revision of one of the best texts in qualitative analysis, speaking of actual chemical reactions says: "There are a host of these, while the ordinary scheme of analysis employs relatively few of them. But it is only fair to assume that most of them were studied for their availability for qualitative analysis during the latter half of the nineteenth century when so much of the exploratory work on reactions was being done and when the main field in chemistry was chemical analysis. There may be better separations than the ones now used, tucked away in the chemical behavior of the metals with known reagents, but it would be an enormous undertaking to conduct the systematic survey of the field that would be necessary to discover them and prove that they are better. There were many men in the past generations ranking high in chemical achievement who devoted a considerable part of their lives to this problem. There are men now living but advanced in years who have carried on where these left off. It would take a courageous optimist to attempt a revision of the present system in the belief that it would be easy to improve." Then after introducing specific organic reagents the authors add: "Probably the greatest hope for improved methods lies in the discovery of more of these specific reagents. Thus far, however, there have been no ways discovered by which one can judge whether or not a given reagent will be of value, and so the search for new reagents of this type is essentially empirical and enormously time consuming. Thus far only one man has undertaken a serious search for such reagents."

This is a fair representation of the attitude of chemists toward analytical chemistry. An examination of several catalogs of graduate schools reveals that only about one-half of those which name fields of specialization within the field of chemistry offer advanced degrees in analytical chemistry. One of the departments which offers a major in the field of analytical chemistry has granted more than 200 doctorates in chemistry in the last 20 years. Not one of these was in analytical chemistry.

Last week a chemist who has worked on analytical problems for 20 years and who now has charge of a large group of analysts said: "Does anyone really plan to do analytical work while in college? I would have been much better fitted for my work if I had done so."

However, there are many indications that the worst of the neglect is past. The existence of a Division of Analytical and Microchemistry, the appearance of Volume XIV of the *Analytical Edition* of *Industrial and Engineering Chemistry* with 100 more pages of articles in the first eight months than were published in the first eight months of any previous year, the number of graduate fellowships in analytical chemistry granted by industrial organizations, and the increasing respect accorded to analytical chemists, show that this symposium is not a turning point but another step in establishing analytical chemistry in the honorable place it merits.

The field of analytical chemistry is broad and its mastery requires the application of many skills, technics, and theories. Besides the precipitation, washing, igniting, and weighing of the old gravimetric analysis, and the making of standard solutions and finding endpoints by means of indicators of the old volumetric analysis, a modern analytical chemist must know how to use microscopes, micro-balances, many types of electrical apparatus and vacuum tubes, spectroscopes, polarized light, and x-ray spectra. Some of us believe that the time has come when students in college should purposefully master the use of the tools of the analytical chemist and enter on their practice equipped to perform their tasks in the best way by using intelligently the most appropriate tools. We hope that this symposium will assist in achieving these results.

The Teaching of Microchemistry[1]

JULIUS ANSON KUCK

The City College of the College of the City of New York, New York City

THE TITLE of this paper as a part of the symposium on the teaching and practice of analytical chemistry is obviously very broad and varies according to the different concepts of the words in the title which each person may have. In considering the value of teaching microchemistry to students as a preparation for industrial work and as a part of technical education in wartime, it is evident that we must first know what part of the subject is under discussion and as a preparation for what type of industrial work. This article will be confined to Pregl analysis and to chemical microscopy.

Likewise, the term "teaching" when coupled with the word "microchemistry," or "microchemical education," if you prefer, must be defined for intelligent discussion. Do we understand the teaching of microchemistry to mean vocational training strictly as such, or do we agree on a broad, liberal education in the field of microanalysis? This question always crops up whenever a group of teachers of any subject meet for discussion. A given individual's point of view seems to depend upon whether he possesses a progressive or a conservative educational philosophy, and this, in turn, hinges upon both his glandular nature and the conditioning of his previous environment. Therefore, there is no point in taking time to argue the relative merits of the vocational versus the liberal school of thought. However, we can perhaps say in a general way that the vocational objective belongs, if anywhere, in the university graduate school which should specialize in professional training. Graduate courses in microchemistry at such institutions should have as their objective the making of a trained analyst. The desirable proficiency which can be obtained by the student only after he has performed many repeated analytical determinations on a wide variety of unknowns involves a considerable expenditure of time, money, and effort and limits the scope of the course.

The undergraduate liberal arts college, in contrast to the university, has as its educational objective "the training of the mind and not the fingers." In all of its teaching it is presumed to assist the adolescent student in orienting himself in a very strange world by acquainting him with tiny samples of the large variety of man's accumulated knowledge which surrounds him.

Some years ago a former president of City College sent a questionnaire to every member of his staff of instruction who was responsible for one of the thousand courses listed in our college catalogue. In addition to requesting the number of the course, the names of the texts and laboratory manuals used, if any, and an outline of the lecture and laboratory content, he appended these three intriguing questions: (1) What mental and physical disciplines do you think that your course gives the student in contribution to his general education? (2) What skills does your course offer the student as a preparation for earning his living? (3) How do you think that your course contributes to a life of greater usefulness and to the general enrichment of human culture?

As instructor in the course in Pregl analysis I answered these questions in part as follows:

> "1. Among the physical disciplines in our course in organic microanalysis the undergraduate receives valuable experience in learning how to grasp and handle small glass and metal objects and how to pick up tiny weights. He must also acquire a steady hand at pulling out fine glass capillaries and in doing delicate glass blowing. He must learn to operate a sensitive machine known as a microchemical balance and he has to handle assemblies of fragile glass apparatus such as the combustion or absorption train or the all-glass methoxyl apparatus.
>
> "As to the mental disciplines, a course in microanalysis teaches the student to think in a quantitative way. It forces upon him the mental habit of cleanliness because he is always working against a low tolerance of error in micro work which prevents him from getting by with slovenly analytical habits as he might be able to do in beginning quantitative analysis."

This means clean hands, clean instruments, clean glassware,—in short, what Pregl termed "microchemical asepsis," if accurate results are to be obtained. The demand for quick mental decisions and for precision of action in the manipulation of microchemical determinations is also a wholesome feature of microanalytical training, as well as is the requirement for originality of ideas in getting out of analytical trouble which was gotten into by a lack of foresight and circumspection.

To the second question, "What skills does a course in microanalysis offer the student as a preparation for earning his living?" the answer is obvious. A training in microchemical technic adds to his potential earning power as a professional chemist.

The answer to the third question, "How does microchemistry contribute to a life of greater usefulness and to the enrichment of human culture?" has infinite variation and can be best left to individual personal opinion. There are any number of human occupations where a knowledge of just the right things in microchemistry might prove very useful.

However, my own answer to the third question is of great importance to me because I am teaching microanalysis in the largest municipal college in the world.

[1] Presented before the Division of Analytical and Microchemistry in joint symposium with the Division of Chemical Education at the Buffalo meeting of the American Chemical Society, September 8, 1942.

This is an institution which has its own peculiar educational problems. For instance, we are always besieged with many more applicants for our microchemistry course than we can possibly accommodate with our available laboratory space, funds, and apparatus. Many deserving students have to be turned away, and of those whose fortune it is to be accepted, many will never enter graduate school for advanced training. Others who may have to accept whatever work they can get after graduation may never see the interior of a chemical laboratory again. Some students may have enrolled in the course because microchemistry appeals to them or because they first heard of the subject in high school and want to see what it is really like. As in any college, less than five per cent of the graduates of ours will probably go on for a Ph.D. in chemistry. Few will be employed in any capacity where they will have any occasion to perform a microchemical combustion.

Common sense therefore dictates that the educational custodian of our course in microanalysis must follow the democratic principle of the greatest good for the greatest number. This we can best do by giving our students as broad and as liberal an education in the field of microchemistry as we possibly can in the limited time at our disposal without neglecting to place sufficient emphasis on the fundamentals of microchemical technic.

With these facts in mind one might be interested in some of the technical details of the microanalytical course which is being given at the present time by the City College of New York. Some features of the lecture and laboratory work are interesting because they are unusual and are not commonly given in courses of this kind. This course is typical in that it is a Pregl course but it is unique in that it is designed strictly as an undergraduate course and in that it has the liberal objective which has been mentioned.

Table 1 is an outline of the lecture topics for the term's work and represents the material covered in fifteen periods, one each week. The course opens with a consideration of the microchemical balance, which seems to be the logical starting point in a Pregl course since all activity in the laboratory centers about this instrument. Not only must the student review what he has previously learned about the balance in his beginning quantitative analysis, but he must also acquire a knowledge of the construction of the microchemical balance and the more important facts in the problem of designing it. This is important because the limits of our present micro-procedures are said to be set not by limitations of our manipulative technic but by the accuracy of the microbalances which we now have. Therefore, the student should be taught the relative advantages of the Mendeleeff and parallel arrestments, the shortcomings of the push-button versus the mushroom type of pan arrestment, and the demands on precision workmanship which the short beam, seven centimeter microbalance entails if a constancy of lever relationship is to be preserved at all times. He should be told that great progress has been made in the design of suitable damping devices which really work for microbalances and he must be taught the factors affecting sensitivity, how to test a new balance for reproducibility, and how various types of microbalance differ, before he sets out to buy one.

Figure 1 is an explanation of the second lecture given in Table 1. It deals with the relationship between the

TABLE 1

LECTURE TOPICS—ORGANIC MICROANALYSIS

City College of New York—Fall, 1942

1. THEORY OF THE MICRO-BALANCE. Definitions. Demands on the Constancy of Lever Relationship. Short Beam vs. Long Beam Balances. Upright, Downward, and Double Triangle Beam Forms. Impairment of the Constancy of Lever Relationship by Temperature Influences, Humidity, Electrostatic Force.
2. THEORY OF THE MICRO-BALANCE. Sensitivity. Determination. Formulas. Inconstancy of Sensitivity as Distinct from Lack of Reproducibility. Constancy of Sensitivity and the Radius of the Knives.
$$D > \rho_1 + \rho_2$$
where $\rho_2 = \frac{\rho_r + \rho_l}{2}$
3. THEORY OF KNIFE EDGES. Kinds of Knife Edge Material. Grinding Knives. Screw Settings vs. Swaging. Testing Knife Edges. Guiglielmo's Method for Determining the Radius of Curvature.
4. THEORY OF KNIFE EDGES. Method of Schmerwitz. Knife Edges and Reproducibility. Types of Beam Arrestment. Types of Pan Arrestment.
5. THEORY OF RIDER ERRORS. Ramberg's Work. Length Tolerance. Angle Tolerance. Types of Rider. Advantages of the Stick Rider.
6. CLASSIFICATION OF MICRO-BALANCES. Refined Assay Balances. Aperiodic Damping. Light Quartz Beam Balances. Types of Suspension.
7. CLASSIFICATION OF MICRO-BALANCES. Inclination Balances. Nernst. Nernst–Donau. Torsion Balances. Salvioni. Joly. Electromagnetic Compensation Balances.
8. WRITTEN REVIEW.
9. CARBON-HYDROGEN DETERMINATION. Pregl Universal Filling. Function of PbO_2. Pyrolytic Decomposition of Various Kinds of Nitrogen Compounds. Van Slyke Wet Combustion. Carbon by the Parr Bomb.
10. STANDARDIZATION OF CARBON-HYDROGEN APPARATUS. DETERMINATION OF OXYGEN. Hydrogenation vs. Oxidation. Cinnamoyl Chloride. Cracking and Methanation Catalysts.
11. NITROGEN DETERMINATION. Dumas. Kjeldahl. Ultramicro Kjeldahl. Standardization of Dumas Apparatus.
12. NITROGEN EXPLOSIVES. Types of Explosives. Examples of Propellants, Detonators, Intermediate Detonators, High Explosives. Analysis of Nitric Acid Esters. Nitron. Nitroglycerine. Semimicro du Pont Nitrometer.
13. HALOGEN AND SULFUR DETERMINATIONS. Classification of Various Analytical Methods. Their Limitations and Advantages.
14. METHOXYL DETERMINATION. Flavors. Drugs. Pigments. Methylated Sugars. MICROCHEMICAL OPERATIONS IN ORGANIC CHEMISTRY. Filtration. Fractionation. Titration. Evaporation. Steam Distillation. Recrystallization. Molecular Weight. MICROMANIPULATION. MICRO-GAS ANALYSIS. DUST ANALYSIS.
15. THE POLARIZING MICROSCOPE. Positive and Negative Crystals. Production of Polarized Light. Retardation. Extinction. The Crystal Systems. The Quartz Wedge. Bertrand Lens. Determination of Refractive Index.
16. FINAL EXAMINATION.

setting of the knife edges and the sensitivity of the micro-balance at various loads. This is an excerpt from an article in the physics literature in which Schmerwitz proved that a falling off of sensitivity with increasing load is not due to any appreciable sagging of the beam under load, as is commonly supposed, and as one may be led to believe from the formula for sensitivity which

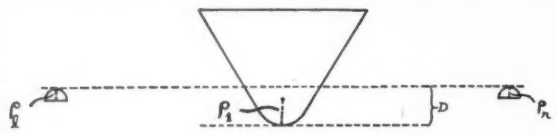


FIGURE 1.

usually appears in the textbooks (*1*). He demonstrated both mathematically and experimentally that if D is greater than $\rho_1 + \rho_2$ where $\rho_2 = (\rho_r + \rho_l)/2$, then the sensitivity of any analytical balance will be quite independent of load within a reasonably wide range. This fact is very important in the behavior of short-beam microbalances where the dimensions of the knives become more significant magnitudes in relation to the other beam dimensions.

Figure 2 shows the geometrical derivation of the formula which is the basis of Guiglielmo's method for determining the central radius of a balance which is listed in the third lecture of Table 1 (*2*). The students learn to derive the formula for ρ where ρ = the radius of the knife, s = the distance of the center of gravity of the beam and pointer from the contact line, θ_2 = the angle of inclination of the balance beam, and θ_1 = the angle of inclination of the central agate plate. This is obvious by an application of the law of sines to the central triangle. If the level of the balance by experiment is changed from AA to $A'A'$, a certain amount of restoring weight will be found necessary to be applied to the lower end of BB in order to overcome the resulting pointer lag. Knowing this weight, the weight of the beam and pointer, and the arm length of the balance, one in effect determines s from the sensitivity of the balance, although it is concealed in the expression which is actually used.

$$\rho = \frac{\text{restoring weight} \times L/2}{\text{mass of beam and pointer} \times \text{angle of tilt}}$$

The student is told to bear in mind that ρ and s are of the same order of magnitude, that they each play an important role in the behavior of the balance, and that all of these mathematical relationships are valid only when the angles concerned are small.

Figure 3 shows the geometrical derivation of Schmerwitz' formula for determining the radius of a knife edge with an experimental glass balance beam which he rested on an upright knife mounted in a theodolite (*3*). The mathematical result works out to be the same formula as that which is the basis of Guiglielmo's method. Schmerwitz found that his experimental beam traveled along the supporting knife when this was rotated through a definite angle, θ_1. In Figure 3 the beam is considered as stationary at the start with the circle O doing the moving. However, the problem is the same, since we are interested in only the relative position of the beam with respect to the knife. When the beam CC no longer rests on the knife edge at its exact center point, the overweight on one end causes it to tilt to its new position $C'C'$ where it stops when its center of gravity s' lies directly below the contact point B. From the geometry of Figure 3 it is obvious that the distance rolled off on the beam AD is equal to $A'B$ + arc BD. The derivation of the formula

$$\rho = s \cdot \frac{\tan \theta_2}{\angle\theta_1 - \angle\theta_2}$$

is then immediately apparent. Schmerwitz found that he could measure θ_1 and θ_2 and that he could locate the center of gravity in the beam accurately enough to determine ρ in this equation. Our students are left at this point to reflect on the validity and actual significance of the measurements which Schmerwitz obtained for various knives.

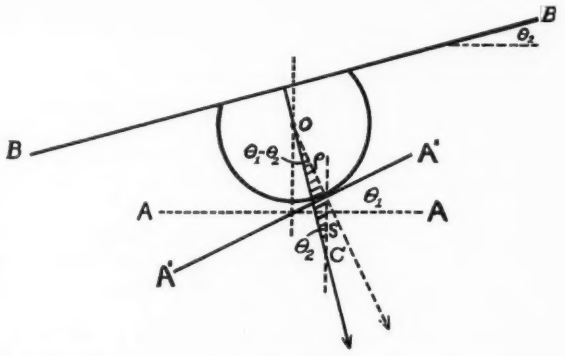


FIGURE 2.—GUIGLIELMO'S METHOD FOR DETERMINING THE RADIUS OF THE CENTRAL KNIFE BY INCLINING THE CENTRAL AGATE PLATE OF THE BALANCE

$$\rho = s \cdot \frac{\angle\theta_2}{\angle\theta_1 - \angle\theta_2}$$

$$\rho = \frac{\text{restoring weight} \times L/2}{\text{mass of beam and pointer} \times \text{angle of tilt}}$$

The theory of knife edges is a very important subject about which little reliable information seems to have been thus far recorded in the literature in spite of the fact that it is directly related to the problem of constructing an efficient microchemical balance. The small but definite dimension of the radius has a profound influence on the sensitivity, reproducibility, load limit, decrement, period, and general performance of the instrument.

There is also a secondary virtue in giving to students such material on the balance. No one really respects the knife edges of his balance until a study of this subject brings home to him the realization of how

small the radius actually is and how uniform the cylindrical surface of the knife must be in order for his instrument to be accurate. Only after this dawns on the student will he release the beam more gently and arrest the swinging beam only when the pointer is near the zero mark on the ivory index plate.

Figure 4 illustrates the content of the fifth lecture in Table 1. This is a summary of some research which was done by Ramberg, of Upsala, and which was published in 1933 as a proof of the superiority of the 2-mg. quartz stick rider over any other style (*4*). The students at City College are taught by means of this diagram and the mathematical formulas which can be derived from it, the concept of the ideal rider and notch, the terms, "carrying line," "division error," "dislocation error," "angle error," "length tolerance," "angle tolerance" (*5*). They are taught how important the design of the rider is, as well as its handling during a microanalytical weighing. They are shown that the length tolerance of the Kuhlmann rider is 7 μ for one microgram. This means that mathematically it is impossible to get a reproducibility of one microgram with a Kuhlmann microbalance if the position of the rider varies more than 7 μ in its distance from the central knife when the rider is lifted up and set down in the same notch for two successive weighings. The students are also shown that the angle tolerance of the Kuhlmann rider works out to 12″ or one-fifth of a degree. This value likewise means that the Kuhlmann rider cannot deviate from a previous angle of setting by more than this value between two successive weighings if a reproducibility of one microgram is to be obtained. Since this angle tolerance value is so small, the student is reminded that in the course of any microanalytical weighing he must always form the habit of checking the rider in its notch in order to see that it not only rests at the bottom of the said notch, but that it also sits there in an upright position.

Topic 6 in Table 1, the Classification of Micro-balances, has been very well laid down in Gorbach's mono-

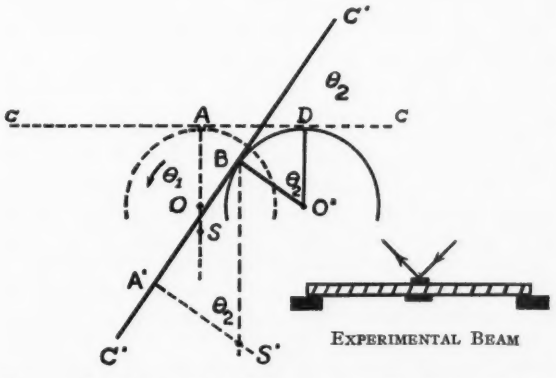


FIGURE 3.—SCHMERWITZ' METHOD FOR DETERMINING THE RADIUS OF ANY KNIFE BY MEANS OF AN EXPERIMENTAL GLASS BEAM

$$\rho = s \cdot \frac{\tan \theta_2}{\angle_1 - \angle_2} = s \cdot \frac{\angle \theta_2}{\angle \theta_1 - \angle \theta_2}$$

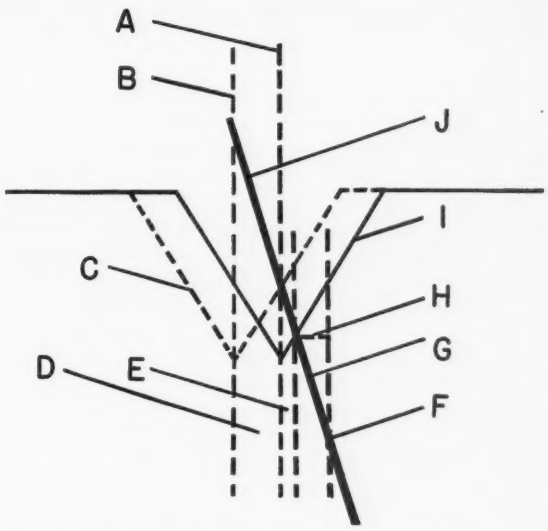


FIGURE 4.—GEOMETRY OF RAMBERG'S EQUATION FOR THE RIDER MOMENT

LEGEND:
A = real distance from central knife
B = correct distance from central knife
C = position of notch in correct division of rider scale
L = distance of carrying line from central knife
ϕ = angle of rider tilt from vertical
$D = \delta L$
$E = \delta' L$
F = center of gravity of rider
$G = d$ = distance of carrying line from center of gravity of rider
$H = d \sin \phi$
I = real notch
J = rider
m = mass of rider
g = 0.980 dyne
$\mu = (L \pm d \cdot \sin \phi)\, m \cdot g$
Error in $L = (\Delta L) = \delta L + \delta' L$

graph on micro-balances, which appeared in *Mikrochemie* in 1936. Here they were classified according to their principles of construction as: (*a*) equal-armed lever balances; either refined assay balances, or light quartz beam balances; (*b*) inclination balances of the Nernst type; (*c*) torsion balances, of either the Salvioni or Joly type; (*d*) balances with electromagnetic compensation; and (*e*) the Ehrenhaft weighing condenser (*6*). The last mentioned is an application of Millikan's oil drop method.

In the ninth lecture, Table 1, the Pregl carbon-hydrogen method and the universal tube filling are discussed. The student is reminded that the universal filling is not always needed, depending upon the type of organic compound which is to be analyzed and that the tube filling can be varied to suit the different compounds which are to be burned in contact with it. This leads to a discussion of the pyrolysis of nitrogen compounds and the function of the lead peroxide.

We consider it very important for the students to know about the Van Slyke ultra-micro carbon determination on tenth-milligram samples, not only because

it is a very sensitive method for carbon, but also because it is an excellent example of a micro wet combustion.

In discussing the standardization of carbon-hydrogen apparatus the student is taught the reasons why each piece of apparatus in this assembly has to be made in the particular design that it is, and why certain dimensions must be considered critical while others are not (*7*). He is not expected to remember the actual dimensions in millimeters, however.

A brief survey is given of the problems involved in the determination of oxygen in which the student is shown the relative advantages and drawbacks in the Ter Meulen hydrogenation and in the oxidation method, when each is used for the determination of the element oxygen in the presence of nitrogen and sulfur (*8*, *9*). The future possibilities of cinnamoyl chloride and alpha naphthylchlorophosphine as reagents for water are discussed in this connection as well as the use of cracking and methanation catalysts (*10*, *11*, *12*).

The eleventh and twelfth lectures deal with the chemistry of nitrogen. The standardization of the micro Dumas apparatus, like that of the carbon-hydrogen assembly previously mentioned, calls for emphasis on the reasons why some dimensions are critical rather than what they actually are. The material on nitrogen explosives is a service designed to meet the present student desire for instruction which is related to the war effort. This is a survey of a few things which have been given in government defense courses and since they are somewhat remote from practical microchemistry, they will be dropped from the course as soon as the war is over.

The various halogen and sulfur determinations in the thirteenth lecture, Table 1, are undoubtedly familiar to everyone and warrant no discussion in this article. Since the student can readily familiarize himself with all of the various important methods by consulting the literature, we do not devote much lecture time to this subject. We might say that we find useful as a mnemonic in student teaching the method of classifying halogen procedures which the Pregl study group of the Metropolitan Microchemical Society worked out several years ago. The students can then be readily taught the limitations and advantages of each of these methods. Among the sulfur methods we mention in passing the industrial titration of $SO_4^=$ by means of the tetrahydroxyquinone indicator and the technic of using a color filter to determine a difficult endpoint (*13*).

After a brief consideration of the methoxyl determination in Topic 14 the major part of the hour is devoted to a consideration of various microchemical operations which are adaptable to use in the organic laboratory. By means of charts and exhibits the students are acquainted with various pieces of microchemical apparatus which are useful to one engaged in common organic research practice.

It is my belief that it is just as important for the student who is going to major in organic research to be taught how to work up a crude material for final micro-analysis as it is for him to know the actual analytical procedure itself, since many laboratories now have a special technician to do analytical work. In my own scientific research where I have access to the services of an excellent professional microanalyst, I find as a rule that I must distil a crude organic oil at least four times before it will yield a precision analysis. If I stop at the third distillation, my analysis frequently proves to be 0.2% to 0.3% off on carbon, and as much as 0.5% on hydrogen, depending, of course, upon the impurities in the particular compound. Our students are warned that mixtures of *cis* and *trans* isomers are especially difficult to purify sometimes, because one never knows just where to cut the proper analytical fraction when the boiling range extends over ten degrees or more. The students are also reminded that every compound which does not possess chromophore groups should be distilled water white before being submitted to the analyst.

The importance of completely purifying solids before analysis as well as liquids should also be emphasized. A solid derivative must be recrystallized to a constant melting point before it is handed in to the analyst, although the mere possession itself, of a constant melting point is not necessarily *prima facie* evidence of chemical purity. At least four or five recrystallizations of a derivative should be performed for a precision analysis and the recrystallization solvent should be varied if possible. Several hours drying also, in the Abderhalden drying pistol should always be considered necessary.

Under filtration and distillation operations in organic chemistry we consider various types of apparatus which are useful for what I choose to call "sub-macro" work, since they are designed for larger amounts of material than those which justify the use of the terms "semimicro" or "micro." For instance, students are taught to fractionate a 3-cc. sample. This is not a micro- nor even a semimicro-distillation.

The methods of reduced concentration and reduced volume are compared under micro-titration. This subject is handled especially well theoretically in Professor Pichler's new book and practically in Professor John's new laboratory manual (*14*, *15*). For students of organic chemistry a good method for the practical microdetermination of neutral equivalent and of saponification equivalent is particularly useful.

Unfortunately Blacet's technic for micro gas analysis has to be presented to our students by means of charts only, and there is time for only a mention of the four technics of dust analysis: filtration, impingement, thermal precipitation, and electrical precipitation, all of which have great social significance to the factory worker in our industrial age.

The last lecture of the term, Topic 15, Table 1, is devoted to the polarizing microscope. This work really has no place in our particular course since it more properly belongs to a course in chemical microscopy. However, since we have no such course at our institution

we include it for practical reasons. By means of carefully prepared charts we can present in one hour a few of the fundamental principles of chemical microscopy.

A list of assigned laboratory experiments is posted in the microchemical laboratory so that each student may know well in advance exactly what work he is to do on each day of the term and can plan for it accordingly. As is customary in engineering courses, every student in ours is required to hand in a preliminary report for each experiment which must be approved by the instructor before he can start work in the laboratory.

The microchemical laboratory at City College is a long, narrow room which can accommodate twelve students at a time. Our three microchemical balances in their protective cases are located along the left side of the room. Across from the balances are permanent setups for the Dumas, carbon-hydrogen, sulfur, and residue combustions. In one corner of the room is a "high vac" pump protected for student vacuum distillation work by a dry-ice trap, and in the opposite corner is a glass-blowing table. Large-scale recrystallizations from alcohol are carried out in an adjacent room and for protection from fire we employ liquid carbon dioxide pressure extinguishers.

Each section has its own weighing tool drawer in which are stored the tares, platinum ware, weighing tubes, absorption tubes, platinum-tipped forceps, prodding wires, and various small pieces of equipment. Each item rests in its properly numbered compartment in this drawer. The halogen filter tubes are kept elsewhere in vertically mounted, large-size test tubes so that their silver halide mats will not be displaced by any shocks occasioned by the movement of opening and shutting the drawer.

Figure 5 illustrates one of the small pieces of apparatus which the students learn to use in preparing compounds for analysis. This is a 5-cc. vacuum-jacketed, vacuum fractionation outfit for taking off multiple fractions. It is especially useful for *cis-trans* mixtures which boil over a wide range. By turning the desiccator-like unit about its upper ground joint, which is greased, one can collect six fractions in the small test tube receivers which are contained in a perforated aluminum block. At the conclusion of the distillation the whole block is lifted out bodily and set on the desk top while the contents of each test tube are pipetted into an analytical vial with a screw cap. Drawn-out capillaries from broken thermometer tubing have the advantage that they can be used over several times as aspirating inlets and are not as likely to break during a distillation as ordinary hair capillaries.

A similar vacuum-jacketed fractionating flask with the conventional "cow" is useful for purifying high-boiling liquids and for distilling high-boiling organic compounds out of tar. The fractionation takes place on a nichrome or platinum wire spiral within the inner column of the distilling flask. The reflux in returning to the boiling flask must flow down the full length of this spiral which is quite considerable when the wire is stretched out straight. The time of contact of the descending liquid and the ascending vapor is thus prolonged. The forerun is collected in one receiver of the cow, the main fraction in the other, and the tail is left in the flask. The small thermometer shown in Figure 5 is of 4-mm. outside diameter, with a tiny bulb, and is held in place by means of a gum rubber slip joint.

FIGURE 5.—MICRO VACUUM FRACTIONATION APPARATUS

The students are also fond of a small 3-cc. distilling flask which has a similar but shorter spiral column. This flask has a short, narrow side arm which opens up into a flaring, bell-shaped receiver for the distillate. In this chamber is a glass overflow pipe which extends for a short distance outside the apparatus and which serves as a connection to the vacuum line. Both the side arm and receiver are located inside the water condenser, making the apparatus both sturdy and compact. We have found the usual aspirating capillary impractical for such small volumes as 3 cc. and have substituted for it a small tuft of glass wool which is held tight against the bottom of the flask by means of a glass rod passed through the rubber slip joint on the side arm. Since the thermometer at the top of the column of this flask coincides with the axis of the side arm instead of with the axis of the column as in the usual case, the distillate can be removed from the apparatus by tipping up the flask until its side arm is vertical, and pipetting the liquid out through the thermometer well. A safety trap immersed in a dry-ice bath serves to condense any vapor getting by the water condenser, although when

the flask is used in actual practice with high-boiling substances, nothing is ever found to collect in it.

Our filtrations are accomplished by means of the so-called filtration adapter, which is useful if several filtrations have to be made. A thick rubber disc, which holds the filter funnel, rests on top of the broad glass rim. If each filter is fitted with an individual rubber disc a wide variety of filter funnels can be quickly interchanged. Interchangeable receivers are attached below. This arrangement does away with the tedious cleaning out of the ordinary filtration flask at the end of each filtration, since this adapter can be rinsed clean in a single squirt from the alcohol wash bottle, and a clean receiver can be quickly attached.

Figure 6 is an illustration of our favorite microbeaker. It has the advantage of a round bottom and yet can stand up by itself. Its contents can be heated by setting the beaker on a low-temperature hot plate, since there is a protecting air bath beneath its round bottom. It has a capacity of 1.5 cc. Crystals and mother liquor are best filtered from this by means of a fine Pregl capillary-tube siphon and a Schwinger filter. This beaker is not yet commercially available, as far as I know.

Let us now briefly consider the teaching of microchemistry in the field of chemical microscopy. The lecture and laboratory topics in courses of this kind seem fairly well standardized throughout the country and need little comment here. They follow the tradition laid down by Professor Chamot of Cornell University many years ago. However, we might note in passing that many of these courses have not been much changed in content since their inception, although chemical microscopy is at present being given both as a graduate and as an undergraduate course in many places. The following are some of the high spots in the usual chemical microscopy course: the optical system of the microscope; the concepts of numerical aperture, angular aperture, and resolving power; the determination of refractive index, the use of the polarizing microscope, quantitative microscopical methods, identification of crystal systems, recrystallization on the slide, chemical reactions on the slide, phase rule studies, conoscopic observation, textile and paper fibers, and qualitative organic and inorganic analysis under the microscope.

FIGURE 6.—MICRO BEAKER

The usefulness of some of this work to one about to enter chemical industry is debatable. For the man who is to become a trained microscopist it is obviously the foundation of his professional career, but the large majority of students of chemical microscopy never become professional microscopists. We find in chemical microscopy, as in the case of other subjects, a considerable time lag between what is being given in the classroom and what is generally being made use of in industry. A certain amount of this time lag is quite proper, for the good teacher must teach only that which is correct and which has been tested. However, the teacher has an obligation to keep up to date and to serve the needs of the majority of his students.

Therefore, the writer, while being unprepared to recommend the elimination of any particular subject material from that which is now conventionally given, would like to mention in a spirit of constructive criticism several topics which he thinks are not receiving much attention in most classrooms where chemical microscopy is being taught, although these things are becoming more and more important in industry.

First of all, it would seem that greater attention should be devoted to the application of chemical microscopical methods in the field of organic chemistry. A student should be taught, for instance, how to tell whether his organic crystals are pure or not when he looks at them with the hand microscope as they grow in the centrifuge tube. He should know how to describe and report correctly the crystal habit of his preparations, and how to distinguish between organic and inorganic crystals when he sees them together on the slide. He should know how to derivatize important classes of organic compounds under the microscope. One thinks particularly of those compounds in which the possibility of several position isomers precludes ordinary derivatization technic, with a subsequent melting-point determination for identification. For example, numerous addition compounds are listed in Garner's "Industrial microscopy" (*16*). A typical reagent is 3,5-dinitrophenanthraquinone, which forms characteristic crystalline addition compounds with a large variety of aromatic hydrocarbons. These hydrocarbons, if they are derivatized by the usual nitration reaction, will yield mixtures of position isomers. The formation of the characteristic crystal form of the 3,5-dinitrophenanthraquinone addition compound on the slide can be accepted as positive identification of a given hydrocarbon in lieu of any organic derivative with a melting point.

Not only addition compounds, but the classical derivatives of various homologous series can be profitably studied microscopically. In recent papers by Dewey and Witt concerning the identification of alcohols by means of the optical properties of their phenylurethanes (*17*), the authors report optical crystallographic data on the phenylurethanes of thirty-eight alcohols and diphenylurea.

TABLE 2

SOME TYPES OF WORK FOR WHICH MICROMANIPULATION IS NOW BEING USED IN INDUSTRY

A. STUDY OF FAILED EQUIPMENT DURING DEVELOPMENT OR AFTER IT HAS BEEN PUT IN SERVICE.

- I. Lubrication of Bearings.
  - (*a*) Particles in Lubricants.
    1. Contamination in Handling.
    2. Separated Additives.
    3. Abraded Bearing Materials.
    4. Rust and Corrosion.
    5. Sabotage.
  - (*b*) Rough Bearing Surfaces.
    1. Inclusions.
    2. Grinding Holes.
    3. Rust and Corrosion.
    4. Amalgamation.
  - (*c*) Filtration Efficiency.
    1. Oil.
    2. Water.
  - (*d*) Lubrication Life.
    1. Studies of Particles, Sludge, Etc.
- II. Foreign Material in Instruments (Hair, Wood, Rubber, Grit).
- III. Sediments in Water, Solvent, or Plating Tanks.
- IV. Analysis of Tiny Parts in Competitive Industry.
- V. Particles Imbedded in Used Brake Linings or Clutches.
- VI. Corrosion of Electrical Contacts.

B. STUDIES IN INDUSTRIAL MICROBIOLOGY.

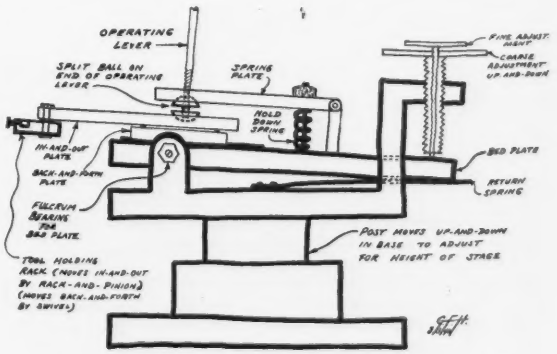
- I. Viability of Yeast Cells.
  - (*a*) Transferring Small Numbers of Colony Cells to the Microscope Slide for Examination and Returning Them to Storage.
  - (*b*) Separating and Isolating Individual Yeast Cells.
  - (*c*) Killing Off Undesired Cells in a Given Colony Which Is to Be Bred for Commercial Use.
- II. Control of Biological and Biochemical Conditions in the Manufacture of Yeast.
- III. Investigation of Yeasts Which Have Not Behaved Properly in the Hands of the Consumer Baker.

The derivatization of alcohols is not always a simple matter for the organic chemist, especially if the molecule contains in addition to the hydroxyl group other functional groups which can be split or changed by the heating of repeated recrystallizations. For practical purposes he usually has to choose between the *p*-nitrobenzoates or the phenyl or alpha naphthylurethanes. The latter are hard to prepare completely free from diarylurea, a by-product which results from the reaction of the isocyanate reagent with moisture. Microscopical identification of urethanes has two advantages: (*a*) the crystals of the derivative can be studied even when they are mixed with those of diphenylurea, and (*b*) binary mixtures of alcohols can be converted into urethane mixtures and the crystals of each component alcohol derivative can be separately identified. Therefore, this type of chemical microscopical training can be considered very useful to the organic chemist.

Micromanipulation is another industrial microscopical technic which is not ordinarily stressed in the average beginning course in chemical microscopy. Here is a little field of knowledge which is expanding rapidly and which has great practical value in commercial work. Its methods have been adopted by the aviation, biochemical, food, and defense industries. It has its own literature which has been most generally recorded in the biological journals and in the Proceedings of the Royal Microscopical Society. The writer is greatly indebted to Mr. George F. Hand of the Sperry Gyroscope Co. and to Mr. F. W. Swift of the Fleischmann Laboratories for information in regard to recent industrial developments in micromanipulative technic. They have very kindly furnished him with the material which is subsequently discussed in this article.

Table 2 is a list of some types of work for which micromanipulation is now being used by industry in the New York area. There are undoubtedly other applications either possible or in present practice which have not yet come to our attention.

From Table 2 it can be seen that micromanipulation is a useful tool in the hands of the plant engineer who has to study the behavior of machines, driving mechanisms, and engines in the modern factory. The lubrication engineer uses the microscope to study the particles which he finds in various lubricants. These particles may have come in through contamination, as a result of careless handling of either the machine or the lubricant. Again, they may result from a breakdown of the lubricant itself under heat, pressure, and friction. A certain amount of the bearing metal may turn up in the lubricant if the bearing surface has been abraded or corroded. In wartime there is also a possibility of grit being deliberately introduced into lubricating mechanisms by plant saboteurs. It is the task of the lubrication engineer to isolate and identify particles which


OPERATING LEVER
SPLIT BALL ON END OF OPERATING LEVER
SPRING PLATE
HOLD DOWN SPRING
IN-AND-OUT PLATE
BACK-AND-FORTH PLATE
FULCRUM BEARING FOR BED PLATE
TOOL HOLDING RACK (MOVES IN-AND-OUT BY RACK-AND-PINION) (MOVES BACK-AND-FORTH BY SWIVEL)
FINE ADJUSTMENT
COARSE ADJUSTMENT UP-AND-DOWN
BED PLATE
RETURN SPRING
POST MOVES UP-AND-DOWN IN BASE TO ADJUST FOR HEIGHT OF STAGE

EMERSON (GEAR SHIFT TYPE) MICROMANIPULATOR

FIGURE 7.

appear in a lubricant from whatever source they may have come.

Micromanipulation is also being used as an aid in checking the behavior of rough bearing surfaces such as clutches and brake bands. Inclusions imbedded in polished metal surfaces may be studied, or the holes which remain after they have been torn from their places by the grinding wheel. Rust and corrosion on bearing surfaces can be differentiated and identified.

In the case of machines which have either a circulatory oil lubrication system or a water cooling system, microscopical studies are being made to advantage on the efficiency of the filter medium by investigating the nature of the contaminant in the filtrate.

Topics II and IV of Table 2 are other specific applications of micromanipulative technic which can profitably be introduced by industries which manufacture instruments containing many fine screws or parts. If a moving mechanism or clockwork stops, the offending particles of fine foreign material can perhaps be isolated and their source identified.

Another important industrial application of micro-

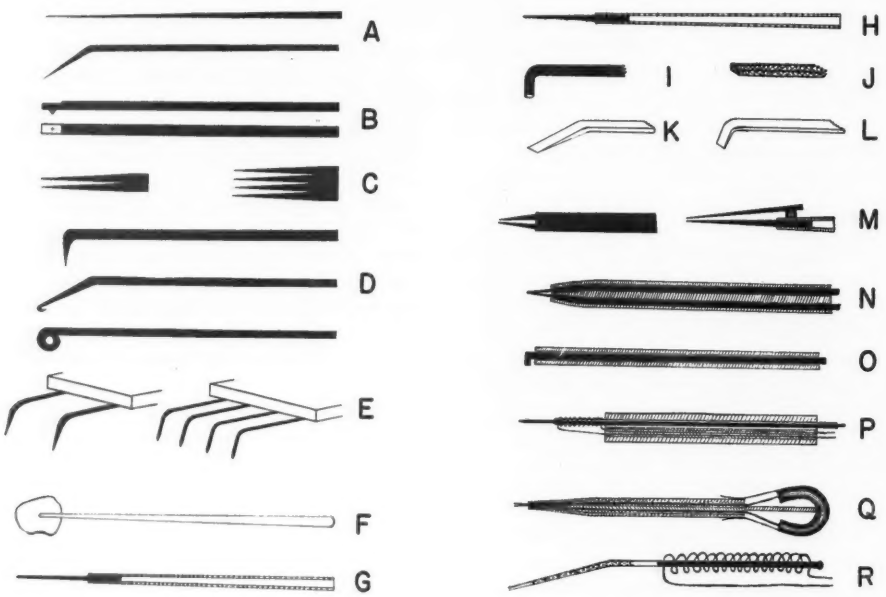


FIGURE 8

MICROMANIPULATION TOOLS AND THEIR FUNCTIONS

	TOOL	FUNCTION	HOW MADE
A.	Pointers	Break up dirt conglomerates Tease material	Grind tool steel to a fine point on rubber wheel ($30 \pm 5\ \mu$ by eye)
B.	Diamond pointer	Scratching inclusions	Mount diamond point in steel bar with Ag solder Line up cross marks on top side
C.	Forks	Transporting material in and out of the field	Fuse together several pointers in their glass capillary or plastic sheaths
D.	Hooks	Untangling textile fibers	Grind tool steel to a fine point. Bend and temper
E.	Rakes	Raking fine material out of the field	Fuse together several hooks
F.	Glass Knife	Cutting biological material	Touch heat-softened glass rod to bubble wall
G.	Steel Knife	Cutting textile and plastic material	Chip out razor blade with jewelers' pliers
H.	Saw	Cutting out metal samples. Making other tools	Etch razor blade and chip out
I.	Hammer	Tapping things into position. Cracking crystals	Grind hook flat at tip
J.	File	Making other tools	Anodized aluminum strip
K.	Chisel	Digging out Fe_3O_4 from rust spots	Grind pointer flat
L.	Scraper	Scraping dirt off textile fibers	Bend chisel and temper
M.	Spring Pointers	Press down to hold beads or spheres	Steel pointers forced into hollow steel tube
N.	In and Out Pointer	Seizing and pulling textile fibers	Movable pointers in glass sheath
O.	Monkey Wrench	Grasping textile fibers	Long-handled hammer in glass sheath
P.	Heater	Evaporating liquid. Testing fusibility of materials	Glass-insulated heating coil around iron rod core
Q.	Magnet	Removing iron particles	Glass-insulated iron wire passing through permanent magnet or solenoid
R.	Pipet	Introducing solutions	Mercury in capillary tube, surrounded by heating coil, expands

manipulation is its use in industrial microbiology. Here, because of its obvious applicability, its usefulness was recognized a long time ago. The growing of yeast cells, for instance, has to be controlled by a microscopical observation. However, delicate technic is required to transfer individual yeast cells to and from the slide and in handling them at will. Under Topic B-I of Table 2 are listed three such manipulative operations which have to be performed many times a day in studying the viability of yeast cells.

The Emerson micromanipulator, Figure 7, of the several models available seems to be most suited to rapid industrial work, because of its ruggedness and simplicity of operation. By means of the "gear-shift" lever, motion of the tool rack is controlled in two directions in the horizontal plane. A thumb screw regulates the vertical motion of the tool rack in space. If the lever is pushed forward, the lower carriage is moved back on its track. The tool rack is correspondingly drawn back, but the image in the field of the microscope moves in the same direction as the gear-shift lever. Likewise, if the lever is moved sidewise, the upper carriage moves on its track at right angles to the path of the lower carriage.

Figure 8 illustrates some of the micromanipulation tools which Mr. Hand uses for metallurgical work. Among these are the various types of pointer, fork, and hook for diagnostic experimentation. Other tools such as the rakes, glass and steel knives, saw, hammer, file, chisel, and scraper are used in performing corresponding mechanical operations under the microscope. The spring and hinged pointers, in and out pointers, monkey wrench, and electromagnet are employed for different grasping operations and the electric heater and micropipet are essential for carrying out microchemical reactions.

If one has access to the proper micromanipulation tools, many microscopical problems prove easy to solve. A collection of dirt and fibers from an oil filter, for instance, is first investigated by removing the dirt particles from the fibers by means of the scraper. By the aid of various tweezers and hooks the various textile fibers can be untangled, isolated, and identified. Inclusions in metal surfaces are studied by means of the diamond-tipped pointer which can be drawn across them to test for hardness. An inclusion may thus be either scratched or completely dislocated. When handling yeast cells, Mr. Swift prefers to use a projection screen in order to eliminate the strain of continual observation through the microscopic eyepiece. He has a very ingenious technic for working in a moist chamber under the microscope and for storing ear-marked colonies for future reference. The yeast cells are handled by means of a suction pipet.

In returning one more to the subject of this article which was the teaching of microchemistry, one cannot conclude without emphasizing that in our present national emergency it is imperative that our teaching standards in microchemistry be maintained at their highest possible level of efficiency throughout the duration of the war. One can be sure that those teaching microanalysis will do their bit in this effort just as will those in other branches of chemical science.

The author wishes to make grateful acknowledgment to Dr. Virgil N. Argo of the Department of Biology at the City College of New York for his assistance in photographing the glassware which is illustrated in this article and for preparing suitable slides.

LITERATURE CITED

(1) SCHMERWITZ, *Physik. Z.*, **33,** 234 (1932).
(2) GUIGLIELMO, *Atti accad. Lincei*, Ser. V, Rendiconti 11, 2° Semestre, 263 (1902).
(3) SCHMERWITZ, *Z. Instrumentenk.* **52,** 1 (1932).
(4) RAMBERG, *Svensk. Kem. Tid.*, **41,** 106 (1929); *ibid.*, **44,** 188 (1932); *Arkiv. Kemi, Mineral. Geol.*, **11A,** 7 (1933).
(5) KUCK AND LOEWENSTEIN, J. CHEM. EDUC., **17,** 171–6 (1940).
(6) GORBACH, *Mikrochemie, XX*, 275 (1936).
(7) ROYER, ALBER, HALLETT, SPIKES, AND KUCK, *Ind. Eng. Chem., Anal. Ed.*, **13,** 574–80 (1941).
(8) TER MEULEN, *Rec. trav. chim.*, **43,** 899 (1924).
(9) KIRNER, *Ind. Eng. Chem., Anal. Ed.*, **7,** 336–8 (1935).
(10) LA COURT, *Bull. soc. chim. Belg.*, **46,** 428 (1937).
(11) LINDNER, *Ber.*, **71,** 1382 (1938).
(12) MARKS, *Ind. Eng. Chem., Anal. Ed.*, **7,** 102 (1935).
(13) HALLETT, *ibid.*, **12,** 360 (1940).
(14) BENEDETTI-PICHLER, "Microtechnique of inorganic analysis," John Wiley and Sons, Inc., New York City, **1942,** p. 234, *et seq.*
(15) JOHNS, "Laboratory manual of microchemistry," Burgess Publishing Co., Minneapolis, Minn., **1941,** pp. 39–41.
(16) GARNER, "Industrial microscopy," Sir Isaac Pitman Sons, Ltd., London, **1932,** p. 146.
(17) DEWEY AND WITT, *Ind. Eng. Chem., Anal. Ed.*, **14,** 648 (1942); *ibid.*, **12,** 459 (1940).

Meeting of Section Q, A. A. A. S.

THE CHEMISTRY section of the American Association for the Advancement of Science, Section Q, has scheduled a most unusual program for the New York City meeting during the Christmas recess. All the living past presidents of the Association, representing all of the important fields of science, are to discuss the question: What Should the Ordinary Person Know about My Field of Science? Section Q is the official sponsor of this program, but all other organizations interested in the education of science teachers are invited to participate.

The meetings will be held in the Hotel Pennsylvania on Tuesday, December 29, from 9:30 to 12:00 in the morning and from 2:00 until 5:00 in the afternoon. On Wednesday, December 30, there will be a morning session only.

HAROLD F. CLARK, *Chairman of Section Q, Teachers College, Columbia University, New York City.*

The Teaching of Quantitative Analysis

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IT IS only necessary to associate with most teachers of college chemistry for a relatively short time to become aware of the low regard in which they hold teachers of education, a group of subnormal individuals they are accustomed to dismiss with a contemptuous: "Well, if the teacher knows his stuff and is enthusiastic about his subject, he doesn't need any half-baked educational theories to help him teach." This attitude is as unfortunate as that of the extreme on the other side where individuals who have had no collegiate chemistry are assigned the teaching of high-school chemistry solely on the basis of their experience in education courses and where a Ph.D. in chemistry is barred because he lacks the requisite teaching certificate. This is state law in many places. Surely, the true answer is some middle course in which the student is given the advantage and assurance of a teacher with a sufficient training in the subject matter, and at the same time a teacher who is cognizant of the limited background of the student and appreciative of sincere student effort.

Probably the most serious limitation put upon us as teachers of elementary quantitative analysis is the deficiencies of our students. This is often more serious than we realize and is certainly not appreciated adequately by the future employers of the students or even by the teachers of advanced courses in chemistry. The remark of one prominent teacher that he taught logarithms with quantitative analysis as a side line is too true to be laughable. Professor M. G. Mellon of Purdue University has a story of the time he investigated a certain student of his who was frequently consulting during an examination what was apparently a crib. The crib turned out to be a multiplication table and the student that day had just mastered the "times sixes." This is an extreme case, but the general level is not so far above this. The high-school training in the basic subjects of mathematics and English is woefully weak, particularly in certain of our midwestern states where the educational control is left in the hands of local boards. A year of freshman work before the students approach quantitative analysis is hardly enough to correct the deficiencies in spelling, arithmetical calculations, and the ability to read a problem correctly.

The failure of the freshman chemistry courses to furnish an adequate background in chemistry for quantitative analysis is even more annoying and a problem which must be handled delicately. The reaction to this problem of a young instructor brought in to teach quantitative analysis in a long-established institution should be a strictly "hands off" policy. Those teaching the advanced courses will quickly make it painfully evident that they have a low regard for the abilities acquired by the students from the quantitative analysis course, and since the quantitative analysis will unquestionably be well taught, it is only fair to assume that the freshman teachers are also doing a good job. Moreover, their problem is more difficult since they are endeavoring to raise an even more diverse body to the level of collegiate study.

Probably the best solution to difficulties of this sort is to segregate the students majoring in chemistry and chemical engineering from those students for whom freshman chemistry is a cultural course, to be taken indifferently or with an attitude of half-hearted dilettantism. This was done at Purdue University. The results were excellent. The undergraduate curricula in chemistry and chemical engineering were greatly improved and at the same time no undue knowledge was imparted to the home economics girls and other students whose predisposition toward chemistry usually makes it impossible to teach them much. Unfortunately the extra burden such subdivision entails is frequently unacceptable to the registrar or administration and often the freshman chemistry staff is so overburdened that it remains lukewarm or antagonistic to the idea.

The segregation of the elementary quantitative analysis students into the various professional groups has been done at a number of schools. The compelling factor for this is usually the fact that the premedical course requires fewer semester hours of quantitative analysis than the chemistry or chemical engineering curriculum. Occasionally such subdivision is dictated by the faculty of some professional school wishing to control more rigidly the subjects which their students study. In a certain degree this may be desirable, but it should hardly be carried to the extent that quantitative analysis is taught in several departments on the same campus. Obviously such duplication of faculty and facilities is wasteful. Chemistry should be taught in the chemistry department. At the same time it is well for the instructor to be aware of pressures from other faculties and, where segregation into professional groups and alteration in the course content appears desirable, to make the concessions gracefully and in a spirit of coöperation. The quarter system, despite its many faults, has more flexibility in accommodating such professional interests. The Iowa State College operates on the quarter system and the elementary quantitative analysis is taught as a three-quarter sequence of courses. The students of all groups numbering about 200 and comprising chemists, chemical engineers, dairy industry, premedic, agriculture, and home economics students, are thrown together for the first two quarters. No effort is made to distinguish the professional groups; an identical, prear-

ranged schedule is used in all of the recitation sections, and the examinations are given to the combined recitation sections at the same time. During the first two quarters the fundamental work of gravimetric and volumetric analysis and the general principles of separations are covered. In the third quarter the class is broken up into professional groups. The chemists and chemical engineers devote the time to brass and steel analysis. The geology students spend the quarter on a rock analysis. The premedic and agriculture students are given further work in volumetric analysis, colorimetry, the determination of pH, the determination of the alkalies in a soluble salt, and are introduced briefly to general technical analysis. The scheme has been in operation for three years and has met with a more than favorable reception.

Fortunately the teacher of elementary quantitative analysis is not faced with a dearth of suitable textbooks. The last decade has witnessed the publication of at least eight outstandingly good texts (*1*). The available texts (*1*, *2*) range from relatively simple books, largely devoid of theory and ideal for the instructor who is otherwise too busy to master the subject adequately, to texts which are almost treatises and contain large portions unassimilable and unintelligible to sophomore and instructor alike. By exercising good judgment and with a little experience, an instructor can locate a text almost ideally adapted to his students and his own needs and abilities.

There is a surprising similarity in all of the texts with respect to the topics covered and the laboratory work presented. This is the result of a great accumulation of experience. The selections are based on a variety of considerations, their industrial importance, their difficulty, the availability of equipment in large amounts, the expense, the ease of securing unknown samples, and the interests of the student and teacher. By and large, the texts are devoted to commercially significant determinations and in this respect differ from the books of certain fields in which too often the content is divorced from practicality and even the problems have an artificial character. The problems given in the quantitative analysis texts often have this same character but they are generally presented in sufficient number and variety for all of the practical problems to be covered. In addition, a goodly number are usually included whose sole purpose is discipline in logic. Representing, as they do, the experiences of authors who are both expert teachers and excellent analysts, the texts offer little opening for serious criticism. Perhaps they place too little emphasis on the methods of sampling and fail to emphasize adequately the importance of record keeping, but these are matters the teacher can easily rectify himself.

The fundamental objectives of elementary quantitative analysis were outlined some years ago by H. H. Willard (*3*) and were summarized as follows:

1. To develop quantitative technic.
2. To point out the nature, significance, and influence of errors and how they may best be avoided or minimized.
3. To use the theories of physical chemistry and to make the procedures of analysis rational rather than empirical.
4. To give the student practice in solving problems, not only those involving stoichiometric calculations, but those involving certain theories, such as solubility product and simple equilibria.
5. To study the related properties of the compounds of various elements such as solubilities, oxidizing and reducing power, and acid and base properties, as brought out by the periodic system and to a lesser extent by their qualitative grouping.

This classical statement of objectives needs no modification, the textbooks are not only adequate but good, and the remaining problem is that of stimulating the student. This is the responsibility of the instructor. Either he has the necessary spark or he hasn't. Professional reputation helps, but with undergraduates, interest is largely aroused by an indefinable combination of qualities in the teacher which includes an obvious, omniscient knowledge of the subject, a democratic approachability, a sympathetic appreciation of effort however deficient, and a readiness of wit which can provoke without stinging.

The only differences of opinion about the method of teaching quantitative analysis center about two topics, whether to teach gravimetric analysis or volumetric analysis first, and how much theoretical physical chemistry to include. In recent years a number of teachers have altered the order of teaching quantitative analysis by teaching volumetric analysis before gravimetric analysis. One reason for making this change is that the students become too easily discouraged with gravimetric analysis and drop out of the course early, whereas volumetric analysis appears to be much simpler and the initial work of the students is more satisfactory. In most quantitative analysis courses, the first determination is the gravimetric determination of sulfate, and it is unquestionably true that a high fraction of the students obtain incorrect results and find it necessary to repeat the analysis. Barium sulfate is reduced by carbon and flame gases with exceptional ease. Indeed, the weight of the normal barium sulfate precipitate obtained can be altered by as much as 30 mg. by changing the position of the flame under the crucible containing the barium sulfate even though the crucible be well inclined to allow access to air. This is a fact not sufficiently emphasized in the elementary books, and one which is responsible for the early discouragement of the students of gravimetric analysis. By paying close attention to the ignition of barium sulfate, the number of incorrect analyses can be greatly diminished and discouragement on the part of the students obviated.

Teaching volumetric analysis first requires that the student learn both the technic of weighing and the technic of volumetric analysis at once. It also demands as a background the simultaneous assimilation of the much more complicated theory and calculations of volumetric analysis. This is an unjust and unnecessary burden to the student and is actually harder on the teacher and student than the more conventional method of teaching gravimetric analysis first. At one institution, the reason that volumetric analysis is taught before gravimetric is to relieve the congestion on the bal-

ances at the beginning of the course. This is an excellent reason, but it follows that to avoid this congestion, the unknown samples must be given out in the form of solutions which are sampled by pipet; this may be satisfactory for one determination, but its application to all of the volumetric work is highly questionable.

A careful examination of the subject matter shows that it is more logical to teach gravimetric analysis first. Certain types of volumetric analysis require a knowledge of the theory of gravimetric analysis and the calculations involved in volumetric analysis can be more simply taught as an extension of gravimetric calculations.

The amount of theoretical physical chemistry which can be forced upon the sophomore varies with the institution, being governed by the initial selection of the students themselves and the adequacy of the freshman chemistry course. Having been trained by teachers whose approach was largely empirical and whose interest lay in the method and the chemistry rather than in the theory itself, the author's personal reaction toward this subject is to emphasize chemistry and the ordinary chemical calculations, and to leave to the teachers of physical chemistry the questions of atomic structure, oxidation-reduction potentials, advanced electrochemical theory, and the modern concept of acids and bases. Equilibrium problems as explained and calculated by the conventional ionization theory definitely are within the grasp of sophomore students and should be given thorough attention. All of the eight texts previously mentioned contain a large portion of theoretical physical chemistry, especially as it applies to the problems of quantitative analysis. One text in particular contains an amount of physical chemistry far in excess of that required for the purposes of quantitative analysis and much of it unquestionably beyond the grasp of most sophomore students. As evidence of this, a more recent edition of this book has appeared with the theoretical matter considerably simplified. Another recent text, ostensibly a text on quantitative analysis, is essentially a text on physical chemistry and was reviewed as such in the journals. Without question an adequate knowledge of physical chemistry is of immense benefit to the practicing analyst, and the more our students can learn, the better. There is, however, a distinct limitation on the amount of material elementary students are able to grasp, a fact which is too generally overlooked by teachers whose own course work is too far in the past. A choice is necessary and at the sophomore stage the primary emphasis should be to impart an adequate background of chemical information rather than a jumbled and partially understood mass of theoretical principles. In spite of the great advances in physical chemistry, most chemical reasoning is still done by the process of analogy, and the greater the mass of chemical facts with which the student is familiar, the more likely he is to have a chemical answer available to solve the problems which he must inevitably encounter in his future work.

Quantitative analysis should be taught as a laboratory course, for this is the only way in which the student can gain the necessary technic and practical experience. A large amount of clerical work in the grading and recording of student analyses necessarily accompanies this laboratory teaching. This clerical work must be meticulously done and only those who have had experience can truly appreciate the tediousness of such work. At Iowa State College, we have developed two mechanical aids which have considerably simplified the work and rendered less possible the chances for errors. These devices make use of the Kardex filing system of the Remington-Rand Company. This system was first applied to quantitative analysis course records by M. L. Nichols of Cornell University; it can readily be modified for local application and is not particularly expensive to install. All the records of the student, both in the laboratory and in recitation, are kept on a single Kardex form. Space is provided for all of the information which is normally accumulated during the course and which should be of permanent record. In connection with this card, a grading system has been developed which enables the calculation of a numerical grade for each student at the close of the course. The grading is done on the following basis:

Recitations	15
Examinations (4 at 10 each)	40
Accuracy of analyses	30
Laboratory technic	10
Notebook	5

At the end of the quarter it is a relatively simple matter to total the points recorded on each of these items, using the spaces provided on the Kardex form, and subsequently to assign a letter grade on the basis of the numerical grade. This scheme furnishes a positive record and, the method of grading having been announced at the beginning, eliminates completely the usual acrimonious post-mortems between student and instructor.

A second Kardex form was designed to simplify the mental arithmetic necessary in grading the result of a student analysis and assigning to it a numerical grade. The card has room for twelve samples, an entire vertical column being devoted to each sample. The following table shows the general arrangement.

1	*2*	*3*	*Etc.*	*Grade*
14.42	13.27	15.39		50
14.32	13.17	15.29		55
14.22	13.07	15.19		60
14.12	12.97	15.09		65
14.04	12.89	15.01		70
13.96	12.81	14.93		75
13.90	12.75	14.87		80
13.84	12.69	14.81		85
13.80	12.65	14.77		90
13.76	12.61	14.73		95
13.73	12.58	14.70		100
13.70	12.55	14.67		*C*
13.67	12.52	14.64		100
13.64	12.49	14.61		95
13.60	12.45	14.57		90
13.56	12.41	14.53		85
13.50	12.35	14.47		80
13.44	12.29	14.41		75
13.36	12.21	14.33		70
13.28	12.13	14.25		65
13.18	12.03	14.15		60
13.08	11.93	14.05		55
12.98	11.83	13.95		50

The correct analysis of each sample is given in the center row designated *C*. The rows above and below the center row contain figures representing deviations from the correct result; the central column contains the numerical grade corresponding to each deviation. Thus a student reporting 13.96 per cent SO_3 for sample 1 receives a grade of 75, and the instructor is not compelled to go through the mental arithmetic of actually computing the deviation from the correct result and of consulting another table to obtain the grade assigned that deviation. Although the initial work in preparing the cards is rather great, the saving in time and mental effort on a hundred samples a day is considerable. Obviously, the greater the deviation from the correct result, the lower the grade. The relation of grade to deviation was worked out from a consideration of the averages of a great number of student results. It varies from determination to determination, depending upon the inherent accuracy of the method of analysis and the ability of the student at the time the determination was made. In general the student is required to repeat the determination if the grade is below 60.

It is absolutely essential for the teaching of quantitative analysis that an adequate supply of carefully analyzed samples be on hand for analysis as unknown samples by the students. Unfortunately, carefully prepared samples are not available on the market and the instructor is required to prepare his own. This is an enormous task, and one for which the instructor will receive little credit other than personal satisfaction. The product is generally buried away in a storage room where it is unknown to the head of the department and the college administration. It is the object of suspicion and dislike by the students. Such samples should be of sufficient number that the results do not become public property by the process of accumulation and comparison of results at the local fraternities. No instructor should ever rest assured that his unknown samples and filing system have not become known by the students. The author well remembers the shock he received during his first year of teaching and the amazement which went about the laboratory when a new series of samples was given out for student analysis for the first time. The students themselves were so puzzled that they came to the assistants asking for help in the genuine belief that they had carried out the analyses incorrectly since they had obtained results which they knew to be outside the range of the samples which had been given out for many years.

The preparation of such samples is not an easy matter from a mechanical standpoint. Certain types of material, in spite of very careful drying, have a great tendency to pack in ball-mills and to defy adequate mixing and grinding. The sample collection at the University of Michigan assembled by H. H. Willard is an extensive one; fortunately his experience has been summarized and made available (*4*).

If possible, the instructor should obtain regular help in the preparation and analysis of new samples. Professor M. G. Mellon of Purdue University, who has perhaps the best collection of samples in this country, has consistently employed from one to three full-time assistants during the summer months, and in this manner has accumulated and maintained an excellent series of samples in adequate number. This is a practice which could well be followed by all teachers of quantitative analysis and an item which should legitimately be considered a part of the expenses of teaching the course. Once obtained, such a sample collection should be carefully stored with adequate protection from leaky plumbing and fire. The large investment in chemicals and the staggering investment in time and effort are ample justification for carrying adequate insurance on such a sample collection; the general reaction of college authorities toward this, however, is violently negative. It is after learning this for the first time that the young instructor must get a firm grip on his emotions if he wishes eventually to retire as a penurious college professor rather than as an affluent industrial chemist.

The value of technical chemical analysis in the quantitative analysis program is a rather controversial point. Certainly, the experiments which the students perform in the laboratory should be those which are used industrially and therefore of immediate practical value beyond the mere exercise and discipline in the subject as a whole. The analysis of water, gas, coal, petroleum products, vegetable oils and fats, and similar products is, however, with the exception of gas analysis, specific in nature, not of broad application, and of little pedagogical value. It is true that occasionally an employer may want a man with training in one of these special fields. Just as often, however, the employer will prefer a man with a broad background and wish to teach him the technical analyses himself. Industrial analytical practice is frequently so far ahead of college teaching, and the colleges so deficient in modern analytical apparatus, that this attitude is amply justified. In any case, the number of students who would subsequently have use for the specific experiments is too small to warrant the expenditure of time by the entire class, and the carrying through of the manipulations on a few specific determinations involving technics which have no application to other problems cannot be justified. This is probably not true of gas analysis, where the technic is a general one which can be applied to a great variety of problems. Gas analysis should be included somewhere in the education of all chemists and chemical engineers. The analysis of coal, petroleum products, etc., is, however, rigidly specified in the official methods of the various testing societies, and anyone with elementary, quantitative analytical training and the ability to read can, with a little experience, acquire sufficient proficiency in any particular analysis to render formal instruction unnecessary.

Work in the analysis of technical materials is, however, taught in at least twenty-five colleges in this country, principally as a part of the chemical engineering curriculum. This is the case at Iowa State College, where the chemical engineers are given a two-quarter

course in technical analysis during the junior year. Without the least feeling of disloyalty the author, in common with many other teachers of quantitative analysis throughout the Midwest, feels that for the most part such work is a waste of time. Although perhaps all courses in technical analysis should not be abolished, the emphasis in such courses might very well be shifted to acquainting the student with the general scope of the subject, its literature, the commercial availability of apparatus, and the practicability of a common-sense approach to the problems of technical analysis in the light of the experience gained in elementary quantitative analysis.

The teaching of quantitative analysis at the graduate level has been much less standardized, and in many schools in this country is practically non-existent. Most emphatically, the graduate training in chemistry should involve advanced course work in each of the fundamental fields of chemistry, inorganic, organic, physical, and analytical, irrespective of the particular field of chemistry in which the student is majoring.

The advanced quantitative analysis taught at Iowa State College is modeled after that taught at the University of Michigan. The work covers two quarters with a total of nine quarter credit hours and is required of all graduate students. The work is divided about equally between the more conventional methods of chemical analysis and physico-chemical or instrumental methods of analysis, and about equally between recitation and laboratory work.

The emphasis in the work in inorganic analysis is thrown on general methods. The topics treated run roughly in the order in which a complete analysis is conducted.

1. The problems of sampling.
2. The methods of decomposing and dissolving various types of materials.
3. The methods of concentrating small amounts of materials.
4. The general methods of separation: the precipitation of the acid-insoluble group, the precipitation of the chloride group, the precipitation of the weak bases, and so on through the various chemical methods and the related methods of separation by distillation, by extraction and by the mercury cathode.
5. The methods of concluding the determination, gravimetric, volumetric, and colorimetric.

Integrated with this work is a great mass of factual inorganic chemistry. As far as possible this material is correlated with the periodic system and the burden of sheer memory work relieved by association of ideas. Necessarily the student learns a great deal of chemistry, but largely as illustrations of general methods rather than as isolated facts.

The laboratory work in this course involves the complete analysis of a plain carbon steel, the determination of chromium, vanadium, and tungsten in an alloy steel, the determination of sodium and potassium in an insoluble silicate, and the complete qualitative and quantitative analysis of an unknown material. These problems introduce the student to a variety of methods of analysis, give him a degree of assurance in having approached and solved some of the more difficult analytical problems, and afford him a brief chance to review qualitative analysis and to exercise his ingenuity in devising a quantitative procedure for a material whose analysis is not well established.

For the course, a text, now in mimeographed form, has been evolved at the University of Michigan and the Iowa State College (*5*). The fairly recent, unique book of Lundell and Hoffman of the National Bureau of Standards, "Outlines of methods of quantitative analysis" (*6*), comes close to meeting the specifications of a text for this course. It emphasizes the general methods of quantitative analysis but is deficient in not having detailed laboratory procedures and sufficient factual material about each element from which the student can derive the basic information needed for solving problems involving the analysis of complex mixtures.

The latter half of the advanced quantitative analysis course is devoted to physico-chemical methods of analysis. No entirely satisfactory text has yet appeared and in a large part the course has of necessity been handled on a lecture basis. Use is made of the texts by Smith (*7*) and by Willard (*8*) over the portion of the work which they cover. The subjects treated in the course include colorimetry and spectrophotometry, the colorimetric and electrometric determination of pH, potentiometric and conductimetric titrations, the polarograph, electrodeposition, and the use of various optical instruments such as the nephelometer, the turbidimeter, the immersion refractometer, and the interferometer. The laboratory work accompanying the course involves work with each of these methods and instruments. Emphasis is devoted to the modern developments of instruments, particularly as they involve vacuum tube apparatus. Some of this material is covered in the course in physical chemistry, but usually only the general theory with little of the practical applications. Thus, in the case of potentiometric titrations, the background of electrochemical theory is presented, but the practical items such as the types of electrodes useful in the various types of volumetric reactions, the ranges, limitations, convenience and applicability of electrodes, differential titration methods, bimetallic electrode systems, and the use of vacuum tube voltmeters to measure the potential are left to the advanced quantitative analysis course. In the interest of conserving the time of the students and of preserving intradepartmental harmony, an effort is made to avoid duplication as far as possible. However, the graduate student body in chemistry at Iowa State College is largely derived from the smaller, midwestern colleges and in general a review of earlier material is usually welcome and occasionally necessary.

Gerald Wendt once remarked that quantitative analysis is to chemistry what algebra is to mathematics and practicing scales is to music. This succinct statement goes right to the heart of the difficulties of teaching quantitative analysis. The prime demands of any quantitative technic are a continued concentration, a high development of resourcefulness and skill, an unyielding personal integrity and adaptability to blunt

contacts with the inflexible laws of nature. Such discipline is more than many souls can bear, particularly if it is suddenly thrust upon them after a quarter of a life of loose thinking. Quite understandably quantitative analysis is unpopular. Quite understandably also there are few enthusiastic analysts and teachers of analytical chemistry. Unfortunately, this early dislike is often carried into later years by chemists themselves and occasionally finds expression even in academic circles as a reluctance to admit the importance of analytical chemistry, and to back adequately the analytical department with a sufficient staff or funds for equipment or to maintain proper advanced teaching in analytical chemistry. Quantitative analysis teachers are thus frequently on the defensive. This is unjust. The importance of analysis is obvious; there would be no advance without it. Although quantitative analysis does have an immediate monetary value, its true value lies in the rigorous thinking, the physical skill, the self-reliance, and the honesty that it fosters. For developing such characteristics, the teacher of quantitative analysis can in general expect little immediate thanks and his reward is usually only the personal satisfaction of doing a good job well.

BIBLIOGRAPHY

(1) FALES AND KENNY, "Inorganic quantitative analysis," New ed., D. Appleton-Century Company, New York, **1939,** 713 pp., $4.00.
HALL, "Textbook of quantitative analysis," 3rd ed., John Wiley & Sons, Inc., New York, **1941,** 364 pp., $3.00.
KOLTHOFF AND SANDELL, "Textbook of quantitative inorganic analysis," The Macmillan Company, New York, **1936,** 749 pp., $4.50.
MELLON, "Methods of quantitative chemical analysis," The Macmillan Company, New York, **1937,** 456 pp., $3.00.
PIERCE AND HAENISCH, "Quantitative analysis," 2nd ed., John Wiley & Sons, Inc., New York, **1940,** 462 pp., $3.00.
POPOFF, RICE, AND CORTELYOU, "Quantitative analysis," The Blakiston Company, Philadelphia, **1935,** 555 pp., $4.00.
RIEMAN, NEUSS, AND NAIMAN, "Quantitative analysis," 2nd ed., McGraw-Hill Book Company, Inc., New York, **1942,** 496 pp., $3.50.
TREADWELL AND HALL, "Analytical chemistry, Vol. II, Quantitative analysis," 9th ed., John Wiley & Sons, Inc., **1942,** 806 pp., $6.00.
VOGEL, "A textbook of quantitative inorganic analysis: theory and practice," Longmans, Green and Co., New York, **1939,** 856 pp., $5.00.
WILLARD AND FURMAN, "Elementary quantitative analysis," 3rd ed., D. Van Nostrand Company, Inc., New York, **1940,** 531 pp., $3.25.
(2) BLASDALE, "The fundamentals of quantitative analysis," 4th ed., D. Van Nostrand Company, Inc., New York, **1936,** 405 pp., $3.75.
BOOTH AND DAMERELL, "Quantitative analysis," McGraw-Hill Book Company, Inc., New York, **1940,** 246 pp., $3.00.
CUMMING AND KAY, "A textbook of quantitative chemical analysis," 7th ed., D. Van Nostrand Company, Inc., New York, **1939,** 469 pp., $5.00.
ENGELDER, "A textbook of elementary quantitative analysis," 2nd ed., John Wiley & Sons, Inc., New York, **1933,** 270 pp., $2.75.
HAMILTON AND SIMPSON, "Talbot's quantitative chemical analysis," 8th ed., The Macmillan Company, New York, **1937,** 297 pp., $2.50.
KANNING, "Quantitative analysis," Prentice-Hall, Inc., New York, **1941,** 460 pp., $3.00.
OLSEN, "Textbook of quantitative chemical analysis," 5th ed., D. Van Nostrand Company, Inc., New York, **1916,** 555 pp., $4.00.
SMITH, "Quantitative chemical analysis for beginning students," 3rd ed., The Macmillan Company, New York, **1933,** 199 pp., $2.50.
SWIFT, "A system of chemical analysis," Prentice-Hall, Inc., New York, **1939,** 589 pp., $6.00.
VOSBURGH, "An introduction to quantitative chemical analysis," Henry Holt & Co., **1941,** 356 pp., $2.75.
WALDBAUER, "Theoretical quantitative analysis," The Blakiston Company, Philadelphia, **1940,** 248 pp., $2.75.
(3) WILLARD, J. CHEM. EDUC., **5,** 957 (1928).
(4) Mimeographed sheets, D. Van Nostrand Company, Inc., New York. See also SMITH, J. CHEM. EDUC., **14,** 241 (1937).
(5) WILLARD AND DIEHL, "Advanced quantitative analysis," Mimeographed ed., Brumfield and Brumfield, Ann Arbor, **1939.**
(6) LUNDELL AND HOFFMAN, "Outlines of methods of chemical analysis," John Wiley & Sons, Inc., New York, **1938,** 250 pp.
(7) SMITH, "Special and instrumental methods of analysis," Edwards Brothers, Ann Arbor, **1937,** 348 pp.
(8) WILLARD, "Laboratory manual for the course in physico-chemical methods of analysis," Brumfield and Brumfield, Ann Arbor, **1941,** 77 pp.

Training of Analytical Chemists from an Industrial Point of View

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ANY DISCUSSION should properly start with a definition of terms, and it is at this point of departure that we shall discover the difference between the academic and the industrial conception of analytical chemistry. Industry is inclined to demand and not to define, and in terms of its demands one can say that the complete analyst should be familiar with all the chemistry of inorganic and organic substances. He should be able to apply with the skill of an expert the technics of all ordinary analysis whether it be the analysis of a silicate rock or the analysis of an organic compound by combustion. He should be a microscopist conversant with all the technics of the petrographer and the biologist. He should be a spectroscopist in

several regions of the electromagnetic spectrum, but covering at least the infra-red, the visible spectrum, and the ultra-violet. Both microscopy and spectroscopy must be supplemented with a practical knowledge of photography which needs a much better background in the theory of the photographic process than any professional operator can get along on. The industrial analyst must have enough of a theoretical and practical background in optics to use intelligently instruments for the measurement of refractive index, dispersion, and the absorption of light. He must know enough of the fundamentals of electricity to make intelligent measurements of current and potential even though they involve the use of vacuum tube circuits as most electrical equipment seems to these days. The certainty and ease with which he must make his decisions must be unaffected by the size, history, or condition of his sample. He must never default on an answer and must always make it with the confidence and certitude of the scientific detective of fiction which is his prototype. If at times he falls short of this ideal, it may not be, I will admit, because of his training, but perhaps because he is still human.

It appears to me that the conception which has been fostered by our texts and courses in analytical chemistry has been much more circumscribed. It is not possible to generalize, especially about as variable a subject as this one, without being wrong; but the impressions that I have formed by my own experience, by conversations with teachers, from an examination of their texts and, perhaps most important of all, by conversations with students lead me to believe that, although I am wrong in some particulars, the academic view of analytical chemistry is closer to that universally maintained a generation or two ago than it is to the realities of today.

Roughly, one may divide the history of chemistry since Lavoisier's day into four periods—the Inorganic, the Analytical, the Organic, and the Physical—in that order. The Analytical Period came to its flower in the second quarter and middle of the 19th century. That this was the classical period of analytical chemistry cannot be doubted when one considers the numbers of our methods which date from this period as well as the kinds and shapes of our apparatus which took form at that time. That the men of this period labored well, there can be no doubt, but that we should assume that the work of the analytical chemist begins and ends with the achievements of this period is our own very great loss. In deciding what the content of a course labeled "Analytical Chemistry" shall be, there is naturally no reason why the academic definition isn't sufficient. But I know that it tends to give the student a misconception of what the analytical chemist's job really is.

In almost every direction we find that the fields of science are becoming hyphenated. We hear a great deal these days about physical chemistry as opposed to chemical physics. The obvious source of trouble with our terminology lies in our methods of classifying these fundamental branches of chemistry and, in fact, of all science. In general we have chosen a historical classification which cannot be defined on the basis of subject matter, or method of approach. Actually there are two directions from which we necessarily work in studying chemical and physical phenomena—the inductive and the deductive or, more familiarly, the analytical and the synthetic. The strictest classification of chemical method and matter can be made on this division of chemistry, and, in fact, of all scientific investigation, into the analytical and synthetic. This enlarged horizon of the analytical domain may seem a little extreme, but that I am not alone in my conception I can assure you by a reference to Dr. Clarke's paper presented in the Symposium on Tools of Analytical Chemistry held at the American Society for Testing Materials Meeting in June, 1940 (*3*). It is in this larger sense that industry is interested in analytical chemistry, but it is in the narrower historical sense that many of our courses are formed and our textbooks are written. Too often the student carries away with him the impression that analytical chemistry has no greater content than the manipulation of cut and dried procedures. Too frequently a teacher will recommend a student with the damning label, "Unimaginative, suitable for analytical work."

That something is wrong with this state of affairs is evident from the amount that has been written in recent years about the content of analytical chemistry and methods for training analysts. Dr. Lundell's article on "The chemical analysis of things as they are" (*16*) is an excellent exposition of one phase of the problem, and I should like to remind you here of his distinction between "analysts" and "determinators." The analyst, as you may gather from his title, performs chemical analyses and what some of the implications of this term are, has been ably expressed in Dr. Lundell's original article. The determinator is an operator trained to a level of manipulative dexterity which enables him to carry through prescribed procedures, but is not capable of exercising the critical faculties and judgment which are expected of the analyst. My own remarks in this paper are concerned entirely with the analyst.

Another series of papers (*4*, *5*, *6*), which indicates some of the questions perplexing non-academic analytical chemists, is by Dr. Beverly Clarke of the Bell Telephone Laboratories and his associates. To these should also be added the preface to Dr. Clarke's paper (*3*) mentioned previously. These men have ably expounded their views which I shall not repeat, but I do wish to endorse what they have said most heartily.

THE DEMANDS OF INDUSTRIAL ANALYSIS

Now the question becomes, what should constitute the training of an analytical chemist and how should it be given to him? First let us consider the problems which the analytical chemist is supposed to meet. He will be expected to know how to perform quantitative analyses on any types of inorganic material by classical methods, but he will discover that while a few years ago he might have been able to characterize most steels

by the determination of phosphorus, manganese, silicon, carbon, and sulfur, he is now likely to find almost any element in the periodic table as an alloying element. If he wishes to determine lead in steel, he will find that Gmelin's Handbuch in the 8th edition states (*9*) that there are no methods in the literature up to May, 1938, for the determination of lead in iron and that references of any kind are rare, but a leaded steel alloy has recently come into quite common use. He will find that, although it was once possible to satisfy a metallurgist with any constituents present in steel above a concentration of 0.1%, the metallurgist demands to know more and more about the constituents present in hundredths, thousandths, tens of thousandths, and even beyond. Not only do these demands come from the metallurgist, but from the ceramist and others working in the fields of applied inorganic chemistry as well. The whiteness of titanium oxide as a pigment is impaired by the presence of traces of other elements such as chromium. And if the analyst is examining titanium dioxide for the electrical engineer, he will probably have to tell him whether it is anatase or rutile. The electrical properties for these two different crystalline forms of titanium dioxide are very different. The phenomenal developments of petroleum chemistry and of other synthetic organic industries are demanding more precise analytical data.

The list could be greatly lengthened, but it means that the analyst must be able to work over extreme ranges of concentration, and must answer questions about materials which have never been raised before. The growing care with which the various steps of manufacturing processes are now controlled calls for remarkable speed in many types of analytical work. The way that spectrographic analysis permits the rapid determination of the composition of iron and steel is a familiar story by now. The determinations can be made at a rate of at least one a minute so that more complete analyses than were ever possible before can be carried out while a heat of steel is held. The analyst must employ for his purpose a vast variety of physical tools—the spectrograph, the microscope, the polarograph, the electron microscope, electron and x-ray diffraction equipment, cell systems for potential measurements, and even, as Dr. Clarke remarks, "medieval history if it will solve the problem" (*6*). It is not in industry alone that such demands are made on the chemist. Medicine, archeology, and agriculture present problems just as challenging in their novelty and diversity to the analytical chemist.

Interesting and provoking problems of a qualitative nature are common. The problem of aging and corrosion is universal and costly and the first clue to what has happened when a metal corrodes, comes from the products of the corrosion process. A knowledge of microchemistry, electrochemistry, of geological and bacteriological processes, of colloid chemistry and metallurgy are all likely to be brought to bear before a satisfactory explanation of what has occurred can be reached. Every such problem is likely to be different and I can say from my own experience that the results are likely to be unpredictable, surprising, and extremely interesting. Qualitative analysis may be called upon to identify intergranular material in metallurgical specimens, or tarnish coatings on metals that vary from a mil in thickness down to a layer of molecular dimensions. Spectrographic, electrographic, and electron diffraction methods must frequently be employed on problems of this kind, and it is quite safe to say there is no blanket or cut-and-dried solution for them. I could multiply instances indefinitely of unusual types of quantitative and qualitative problems, but I can say more about those when I am talking about the equipment which the graduating analyst should carry with him into the industrial field.

TRAINING THE ANALYST

It is not my intention to imply in speaking of the training of analytical chemists that all these things should be given to them in a course of one, one and one-half, or even two years labeled "qualitative and quantitative analysis," nor that the complete analyst can be produced by the amount of training available to an undergraduate in even outstanding schools of chemistry. The training that I should like to suggest would be difficult to complete even in the course for a doctor's degree, but the teacher of analytical chemistry can bring to a focus, can unify and coördinate the training of his students, can give it direction so that they may appreciate the importance of bringing to bear on analytical chemistry other factors in their training. The scope and interest of analytical chemistry are the things which the student must be brought to realize.

SKEPTICISM AND JUDGMENT

The first element that one should seek to develop in the analytical neophyte is fundamental to all science but is nevertheless too important to pass without mentioning—and that is the quality of skepticism. He must be skeptical about his reagents, his equipment, and about what he is told. Skepticism should begin with the sample and continue to the final report. Some of the most humbling surprises which have occurred in my own laboratory have happened when precipitates of allegedly known composition obtained by painstaking separations by a gravimetric analysis have, after weighing, been submitted to spectrographic analysis. Tin oxide sometimes contains most of the periodic table, magnesium pyrophosphate sometimes turns out to be manganese pyrophosphate, and aluminum oxide has been found with almost every element from the original sample but aluminum. Let me remind you that Dr. Lundell has also discussed the importance of this skeptical quality.

Closely allied to skepticism is judgment in the choice of analytical method and, perhaps most important of all, judgment in the choice of method which will best serve the end of the analysis. To take a very simple example, I was once called upon to determine whether a corroded soldered joint in copper wire had been made

with a zinc chloride flux. Since the corrosion had presumably come from the presence of chlorides derived from the unauthorized use of a zinc chloride flux, the metallurgist desiring the test asked that chlorides be determined. Now although chlorides can be detected at low concentrations, they are much more widely distributed than zinc and could have contaminated the sample from ordinary handling. On the other hand zinc can be detected at extremely low concentrations by the use of the spectrograph even though it is not easy to establish by other chemical methods Provided then that there was no zinc present in either the copper or the solder, its presence on the joint would be more conclusive evidence of the presence of zinc chloride than the chlorides. It was a simple matter to remove small amounts of the solder and wire from the joint, prove the absence of zinc, and demonstrate its presence in the corrosion. It is this type of judgment that must be continuously exercised and is welcomed by the metallurgists, engineers, and others with whom the analyst must work and for whom most of his results are obtained. If the analyst adopts a passive attitude and treats his work routinely and indifferently, he is naturally not likely to arouse interest on the part of his colleagues. It has been my own experience that there is a great deal of interest in what the analyst can do, and if he undertakes a little missionary work he will probably be surprised at the response he can awaken.

To return to the exercise of skepticism and judgment, I should like to re-emphasize the importance of arousing in the analyst a deep suspicion of every sample he analyzes. The subject of sampling has been so well treated in many other places that I need do no more than mention it, and add my own warning that seldom is a sample really homogeneous. Not infrequently it is unintentionally and sometimes knowingly contaminated by the people taking it, by bacterial action, and by sheer accident.

EXPRESSING RESULTS

It is surprising to me to find so many analysts who are unable to keep good notebooks. The difficulty is usually of two sorts, one is a matter of indifference and the idea that all the details can be remembered and so need not be written down. The other cause of poor notebooks is the idea that they are sacrosanct and must have a tidiness and beauty which can be achieved only by writing the original observations on paper and transfering a skeleton of the less unsightly data to the notebook. In my opinion the prime desideratum is to get as many details as possible into the notebook, and the second to organize the information in a logical way which will be understandable to anyone who needs to consult the notes. I need not go into the desirability and importance of keeping a notebook properly, nor to dwell on important legal aspects, but I do wish to say that it is rare to find the person who does so. Perhaps the use of textbooks and printed directions tends to stultify the students' recognition of the importance of a good notebook. Frequently this realization comes when at some later date he refers to notes of the past only to find they are not complete. But I must also admit that one of the best notebooks anyone in our laboratory has kept was that of a boy without any college training, and with only limited experience.

Records and reports go hand in hand, and it is important to have materials analyzed, unequivocally identified in both places. The report should then set forth the findings in so far as they are of interest to the person getting the report, and they should be plainly separated from the inferences and conclusions to be drawn. For example, in reporting the tests on the corroded soldered copper wire mentioned previously, it is quite improper to say that a zinc chloride soldering flux had been used—but it should be made plain that zinc and chlorides have been found and that, since they are not present in the metals, and since no other source of these substances can be suspected, it is inferred that a zinc chloride flux had been used. It is surprising how commonly the facts and inferences are garbled in written reports, and how often we can forget that evidence is frequently circumstantial.

It seems odd that I should have to mention that reports should be accurate with respect to findings, but the frequency with which decimal points are misplaced and factors of two or three are incorrectly used in calculations by even experienced chemists is really extraordinary. When the results are written, the custom of placing a zero before the decimal point when data less than 1.0% are reported, is more honored in the breach than in the observance. The custom of totaling results which should add to 100% is also frequently overlooked. A show of discipline in certain mechanical features of organizing data will help to increase the accuracy with which computations are handled.

ERROR AND STATISTICS

It should be the motto of every analytical chemist that "a false result is worse than no result at all." A false result causes the one who uses it to proceed with confidence on an assumption that is not true, whereas a person proceeding in the knowledge that he is ignorant does not leave himself open to the experience of unpleasant surprises. The analyst must fortify himself with confidence in his own results, and must be able to state precisely what these results are.

Closely allied with the recording and reporting of data is the determination of the magnitude of their error. This is a most important phase of the analytical chemist's job and one which I think has been more neglected than almost any other. Unlike the synthetic chemist, the analyst usually has nothing concrete to show for his labors—everything goes down the sink, but a few numbers and a short verdict. It is supremely important that the most exact interpretation possible should be given to these results (*17*). We speak loosely of the error of an analysis, but what do we mean by it in precise terms? Suppose, for example, the specification of the copper content on an alloy is given as 84.0 to 86.0%. What interpretation are we to give to this

specification? If we make a single determination of copper by electroanalysis and it falls in this range, say at 85.0%, we could say with confidence that the sample meets specification. If, however, the same specification had been set on aluminum, we could not have anything like the same degree of confidence in our result. How, then, can we establish the accuracy of our results? The certainty with which we can report any result will depend on the method and on the number of determinations. It is just as important to realize that in writing the specification, the limitations, with which the tests on the material can be made, must be recognized and the error of a determination series or determinations must be known.

A fine example of the importance of knowing with certainty the degree of error in one's analysis is provided by Lord Rayleigh's letter to *Nature* (*18*) regarding his results on the density of nitrogen. In spite of his reputation he does not hesitate to state bluntly that he is puzzled by results which he cannot explain within the limits of the error of his experiments. The pursuit of the source of this error led eventually to the discovery of the rare gases. I have frequently cited this example to workers in our own laboratory who are inclined to respond that such confidence was all very well for Rayleigh to display, but for the ordinary mortal such a risk is great. To which I respond that after all Rayleigh had a lot more to lose. What we must try to do is to instil in the analyst the conviction of his results, and I think that this can best be done by making him understand the probabilities with which he is gambling. His confidence and convictions will grow with his ability to assess the value of his results. And this ability will come with an understanding of the nature of error in his observations.

It seems to me that to the analyst the theory of errors is more important than the Nernst equation or solubility product concepts. Presumably his work may be restricted enough so that he may avoid the use of these very useful generalizations, but every observation he makes by any method is always limited to a degree which can be predicted only by an intelligent application of this theory of errors. It should be emphasized also that this intelligent application cannot be made by anyone not thoroughly conversant with the actual method or set of results to be evaluated (*7*). In other words, it is a job which can be done better by the analyst than it can by a mathematician unfamiliar with the significance of the results he is treating.

One important branch of application of the theory of errors is in the field of statistics. Economists, biologists, and psychologists have been quick to perceive its importance and usefulness for handling large numbers of observations, but to my knowledge it is not yet recognized as part of the indispensable equipment of the analytical chemist. There are innumerable applications in the industrial field as it is frequently desirable to apply statistical results to determine, let us say, the variation of a physical property with composition. Often the analyst must try to tell whether the moisture content of paper can be correlated with its tensile strength, or whether the toughness of steel can be related to its manganese content and, if so, by what expression. Sometimes the application is in the chemist's own work; for example, when the density of a solution is to be related to its composition or the intensity of a spectrographic line obtained by arcing a metallic specimen is to be related to the variation in concentration of the element giving rise to the line. Much as I should like to enlarge on this topic, this is not the place for doing so. However, should anyone be interested in assembling information about the usefulness and practical application of statistical theory, I have assembled a brief bibliography of books which we have found useful in our own laboratory.[1] A study of some of these books will help the analyst to increase immeasurably the significance of his data.

I should like to mention here a fallacy which has widespread acceptance, particularly in industrial laboratories, and that is the "constant error fallacy." It is commonly but incorrectly supposed that for routine control of a product or process an analytical determination may differ from the true composition by a constant amount without affecting the usefulness of the results. Now to a very limited extent under given conditions this may be true, but eventually this postulate is stretched into the belief that any test is sufficient and adequate so long as it is performed in exactly the same way each time. Emphatically this is not so, and it would be better to abandon methods involving constant errors completely rather than encourage such a misconception.

The expression of results in understandable English is closely allied with the expression of results numerically. Much has been said and written (*2*, *14*) on the appalling inability of scientific men in general to use language properly. I suspect that it is partly because they have not been sufficiently encouraged to take seriously their literature courses as students. Yet by so doing they are assuming a handicap which lasts all their lives, unless they are able to overcome it later on. My own company has upon occasion conducted courses designed to correct this deficiency among its scientifically trained employees. Could not the importance of English be brought to the attention of analytical students as a valuable accessory in recording and conveying the results of their labors?

Closely associated with the problem of creating a word picture is the problem of creating a good photo-

[1] A.S.T.M. Manual on the presentation of data [American Society for Testing Materials], Philadelphia, Pa., 1933.

GIBBS, "Adjustment of errors in practical science," Oxford, 1929.

KÜSTER AND THEIL, "Logarithmische Rechentafeln für Chemiker etc.," 41.–45. Auflage, W. DeGruyter and Co., 1935, p. 146.

PEARSON, "The application of statistical methods to industrial and quality control," British Standards Association, 1935.

SHEWHART, "Economic control of quality of manufactured products," D. van Nostrand Company, Inc., 1931.

SIMON, "An engineer's manual of statistical methods," John Wiley and Sons, 1941.

YOE AND CRUMPLER, "Chemical computations and errors." John Wiley and Sons, 1940.

graph. It seems to me that because of the level of importance to which it has progressed, the art of photographic recording can no longer be ignored. There is an oft-quoted adage about a single picture being worth a thousand words, and one may supplement this estimate by saying that a picture can sometimes do what words cannot. However, the photographer like the artist has a problem in learning how to record and represent what he wishes to have conveyed to the beholder. This is a valuable tool which is often considered in colleges and universities to be outside the circle of their instruction and only suitable for the trade school. Fortunately the growth of photography as a popular hobby has done much to counteract this deficiency. But there is a great deal to photography as a science that cannot be separated from photography as an art, and so far as I know there is no place where instruction in the scientific aspects is given much attention. Moreover, photographic emulsions are exceedingly important as a means of making measurements of energy, both qualitatively and quantitatively. The reactions of photographic film both to radiation and subsequent development are complex and must be understood before they can be handled intelligently. There has been little written in book form about this phase of photography, but the nearest to filling the need is the "Wissenschaftliche Photographie" of Angerer (*1*).

Finally comes the most important aspect of any report, and that is showing its significance or drawing the conclusions. It is here that one of the grossest misconceptions of the function of an analyst seems to lodge. The first is that an analyst can perform an analysis without knowing what significance his results are supposed to have, and the second is that he is indifferent to the significance of his results. As evidence that this belief does circulate, I can cite the denials of its validity by Van Brunt (*20*) of the General Electric Company in Schenectady, who states: "the chemist here finds himself in the position of a physician to ailing inanimate creation; he must diagnose and at least coöperate in prescribing remedies," and from Clarke (*6*) of the Bell Telephone Laboratories who says: "The chemist competent to serve in this capacity must be much more than a mere analyst. He must first of all have the mental outlook of the research consultant; and this involves considerable knowledge of the non-chemical technology of the particular industry, and familiarity with materials gained through experience, as well as a thorough grasp of all the pertinent branches of chemistry." To these statements I should like to add my own, that analytical chemists do have an opportunity to exercise their critical faculties.

TOOLS, TECHNICS, AND COURSES

The undergraduate course of one or two years in analytical chemistry as it is now given does give the budding analyst a sufficient knowledge of the theory of solutions to enable him to work intelligently with the various procedures and schemes of separation which form the analyst's stock in trade. He usually acquires sufficient manual skill so that he can actually perform an analysis of not too great complexity with a fair degree of reliability, and in the course of this process he acquires a knowledge of a limited number of classical schemes for iron, non-ferrous metals, or mineral products. This represents only a minimum of desirable experience, and even the advanced student who does a complete silicate rock analysis seems to be rare. This lack of experience among graduates was decried in 1917 by the late Dr. Hillebrand (*12*), and judging from a recent report in *Chemistry and Industry* (*19*), it is still a difficulty with the students graduating in Great Britain.

The criticism is a difficult one to meet as it would be calamitous to load down the curriculum with too many mere procedures. Most procedures in the analytical course are quite properly chosen to give the student an acquaintance with the general schemes of separation, and the successful manipulation of these separations is the keystone in an analytical chemist's training.

There has been a tendency to reduce the extent of analytical courses from two years to one year. In some schools one year was devoted to qualitative analysis and another year to quantitative analysis. The reduction in the time given to qualitative analysis is probably quite justifiable. The old qualitative scheme of analysis hasn't much more value that its pedagogical usefulness. There are seldom occasions when it needs to be used. The spectrograph and specific reactions are doing much to supplant its practical usefulness, and the growing importance of these and microchemical schemes are quite properly crowding the place the old qualitative scheme once enjoyed. It does provide the student with preparation for the all-important separations of quantitative analysis. Unfortunately the abandonment of the old-fashioned qualitative analysis has not been followed by a substitution of any other analytical work and the curriculum is impoverished of its opportunities for students to develop as analytical chemists. And whether a student will be an analyst or not, he will still have many analytical problems to solve in his chemical career.

Qualitative organic analysis is probably one of the best tests of reasoning power to be found in the chemical curriculum. Inorganic qualitative analysis has come close to being a cut-and-dried procedure. but there is no fixed set of rules which, without some knowledge of the reactions, structures, and processes involved, will lead to the correct conclusion when applied to the analysis of an organic substance. Industrial qualitative organic analysis is even more taxing and calls for a high degree of ingenuity which is not common. Not only must the industrial chemist deal with natural products which are usually mixtures and which may not be described in the literature, but he must also deal with synthetic products whose nature may not be known even to the manufacturer and whose preparation may be a trade secret. These products are frequently secondary—that is, a chemist must try to tell from a varnish film what the original varnish was like, although the film may be modified by drying, baking, etc. An

excellent knowledge of synthetic organic chemistry must be used to tell how the end-products can be derived from a set of starting materials selected from possible alternatives. The analyst's training should include a good opportunity to exercise his abilities by the unique opportunity offered in organic qualitative analysis.

There is a further question in the education of analysts which ought to be discussed at some length and that concerns the matter of instruments. Some instruments that the analyst uses do not necessarily need to be understood from a technical point of view—for instance, in electro-analysis he must use a generator or set of batteries to supply power for the electrolysis. And so long as the analyst can read a voltmeter and ammeter and understand their significance, he is not likely to have to know much about the operation of either the batteries or the generator set. However, when he comes to the use of a potentiometer or a spectrograph or spectrophotometer, this situation does not apply, for the analyst must know the limitations of his instruments and how to use them at the limit of their efficiency. When it is a question of mere battery maintenance or operation of a generator set, he will be supplied with a set of the manufacturer's instructions and these will serve to guide him in a reliable manner. However, when it comes to the limitations of instruments that are to be used for measurements, the guides are not so reliable. There are, of course, some manufacturers who can be relied upon to describe the performance and limitations of their equipment with strict accuracy. But there are others who believe that scientific equipment can be sold with the extravagant claims of popular advertising. For example, one photoelectric spectrophotometer is described by its manufacturer in comparison with visual instruments as having "Another advantage [is] that anyone can make the readings. Two or more analysts will always get the same results, and there can be no possibility of disagreement." Obviously such a statement is based on a false conception of the accuracy of any physical measurement. For further examples of this same sort of misleading information, you will find a discussion in an article by Dr. Gibson (*10*) of the Bureau of Standards. Similarly it is sometimes possible to find extravagant claims made for glass electrodes used for the measurement of pH. As the use of instruments grows, we must counteract this tendency by awakening in the prospective users of instruments a critical attitude which will probably do much to eliminate the carelessness with which claims are made.

I should also mention the kinds of instruments which the modern analyst is likely to find useful for his work. They include among the optical instruments the spectrograph, the refractometer, the spectrophotometer, and the microscope. Why the latter instrument finds so little use in the training of analysts, I am not quite able to understand. It is well known and much used among scientists, but it is only the biologists or geologists who really seem to give the student a chance to use it. Even then the students are unacquainted with the fundamental principles of illumination which are necessary if the instrument is to be used to its full effectiveness. One needs only to recollect the great usefulness in commercial work of identifying fibers, foodstuffs, soils, minerals, and the use for microchemical reactions to realize what an important loss this is.

The proper use of electrical equipment must naturally be taught in a course on electrical measurements. Many analytical students never seem to discover that there is anything more to the operation of a potentiometer than reading a dial. Yet the use of galvanometers, potentiometers, vacuum tubes, resistance and capacity bridges, and, more recently, the electron microscope is bringing to the hands of the analytical chemist more and more instruments whose fundamental mode of operation is electrical and can only be understood by a grasp of electrical principles. To say that these are not the business of the analytical chemist is much like saying that he need not know how the analytical balance functions because its operation is a problem in mechanics.

The growth of microchemical technics is an extremely important one to analytical chemistry, and it is to be hoped that in giving such training the student will be indoctrinated with more than one school of microchemical thought. A tendency seems to exist to prefer one particular system to the exclusion of others, when it is obvious that each has certain advantages. Perhaps one of the best ideas for the student to carry away is that microchemistry is not the exercise of a system, but is a rapidly developing technic utilizing any means suitable to its purpose which is the manipulation of small amounts of materials.

The development of the technic of handling high vacua has had its effect on analytical chemistry, and many forms of gas analysis, such as is encountered in the determination of oxygen in iron and steel, are best handled in a glass system which requires at least rudimentary skill in glassblowing. The importance of vacuum technic is only just beginning to be felt—for instance, in the interesting and ingenious method of Emmett (*8*) for measuring the surface area of powders—and the student should somehow be given an opportunity to gain some acquaintance with these methods.

There is a group of interesting and specialized methods of analysis which cannot be grouped under any mention I have made so far—polarographic methods, chromatography, X-ray diffraction, electron diffraction, the use of tracer elements both of the radioactive variety and of isotopes. It is hardly necessary to mention that the analyst is usually expected to know something about the classical methods of determining density, viscosity, etc.

It may be urged that the list I have given is too largely concerned with physical methods. If so, it is because I believe that here a large deficiency exists in the preparation of the analyst. Certainly if he neglects these methods he does so only to abandon them to the physicist who appreciates their usefulness as analyti-

cal tools (*15*). That chemical analysis is the chemist's job I am completely convinced, and if it is undertaken by a person without knowledge of chemistry it will be everyone's loss. The story has been fairly well circulated of the physicist with his eye on the periodic chart who told his class that having finished consideration of carbon dioxide the class would study the next gas in the same family—silicon dioxide. In performing a chemical analysis the analytical chemist has a distinct advantage in having been trained to understand the phenomena he is observing. The only analyst likely to know whether sulfites can be derived by reducing sulfates is the one who is a chemist by training. The analyst must appreciate the advantage and limitations of both chemical and physical methods to decide which shall be the best for any given use.

Finally for the equipment of the analyst, I do not believe that the importance of knowing how to use the literature of chemistry can be overemphasized. He should, of course, as a very minimum, be thoroughly familiar with the various texts, compilations, and standards in which methods are given, but beyond that, he should be able to find the data of whatever sort he needs in the *most reliable* place, whether it be "Beilstein," the "International Critical Tables," "Landolt-Börnstein," or whatever other place they are recorded. He should also be made to realize that useful information for the analyst can be gleaned from other than obvious sources. For instance, useful information on the determination of lead may be found in the methods book of the American Association of Official Agricultural Chemists even though it is not a metallurgical methods book. He should further realize that there is useful information to be found when analyzing minerals, in such places as the "Data of Geochemistry" and the "Handbuch der Mineralchemie" of Doelter. Even though the literature of chemistry in English has been growing, there are still enough important reference works and enough of the journal literature to consult, to make more than a casual acquaintance with German highly desirable. The analyst ought to be facile in the use of German, and it may take more than a one-year course in scientific German to bring this about. A few schools do have well-organized courses in the literature of chemistry and the advantage to their graduates is very evident and very great.

What I have said has been of necessity long but sketchy. I have not concerned myself with what a student might expect to find within the scope of an undergraduate course labeled "Analytical Chemistry," but with the more important question of what he ought to have in the way of preparation when he leaves the university with the label of "analyst" affixed. Naturally, only a small fraction of what I have mentioned can be given in anything like an adequate form to an undergraduate, but the analytical instructor can do a great deal to inspire and instruct promising students with some vision of the scope and interest which lie in the field of analytical chemistry. It is here that I think one of the greatest weaknesses of modern analytical teaching lies. Twenty-five years ago Dr. Hillebrand (*12*) complained that promising students were not drawn to the analytical field, and I believe there is justification for the same complaint today.

THE DIRECTION OF ANALYTICAL CHEMISTRY

There is great interest in many parts of our large industries today for men who can solve analytical problems. These men are recruited to an alarming degree from other than chemists trained as analysts. This is in some degree a reflection on the whole state of analytical investigation. We have perennial unsolved problems in the determination of common elements like aluminum, zinc, fluorine, and boron, yet we allow people to say that analytical chemistry is a dead subject. We have allowed important analytical developments to go unheeded, and to be developed by others. For instance F. Weigert set forth all the principles necessary for spectrophotometric analysis in 1916 (*21*), yet it is only in very recent years that attention has been paid to this useful and powerful method of analysis. The usefulness of the powder method of X-ray analysis was described by Hull in 1919 (*13*), but it was not until 1938 that Hanawalt's paper (*11*) more or less marked the beginning of the widespread interest among analytical chemists. Even along conventional lines there seems to have been little exploration. Analytical chemistry has developed on the theory of intensive cultivation. Little study seems to have been made of separations in the non-aqueous solvents such as ammonia, selenium oxychloride, sulfur dioxide, or organic solvents. No very extensive exploration seems to have been undertaken of the numerous complex radicals to find out whether or not there are applications such as has been made of potassium cobaltinitrite or ammonium hexanitrato-cerate. The only separation method based on extraction which has found wide application has been of ferric chloride with ether. There has been little radical change in the schemes we have developed for an analysis such as of bronze. I have often wondered why determinations for some elements seem to be so easy, while for others they seem to be difficult. It is hard to find any fundamental reason why copper should be a relatively easy element to determine in almost any concentration by a variety of methods, whereas aluminum can only be separated and determined with difficulty. There is nothing fundamental to relate the accuracy of the electrolytic method for copper with the enormous number of colored complexes available for colorimetric determinations—perhaps we are too conventional in our approach to the aluminum problem. I mention these things only to point out that with so many problems of such inherent interest and importance, it ought to be possible to meet the challenge of attracting some of the best students to the analytical field. Certainly we cannot say that our subject is an exhausted one, when so much has never been tried and so much has been only imperfectly accomplished.

Finally, it must be remembered that anything that the student receives by way of training may be nullified by lack of accommodation to the social demands of industrial chemistry. They are not very taxing, but often students find them difficult. All that I should like to say here is that the student should be reminded once or twice that such demands exist; and if he cannot test his own reactions by summer work, which is an excellent introduction to industrial chemistry, then he would do well to read over some of the discussions which have been published in forums on the subject (*2, 14*).

In summation, then, I should say that in my opinion the teaching of analytical chemistry can best be served by attempting to inject into the course a larger view of what the subject means. Coördinated, planned programs to provide the student with an acquaintance of the extended ramifications of the subject as it is practiced today ought to stimulate greater interest and draw into the analytical group a larger representation of the best students.

LITERATURE CITED

(1) ANGERER, "Wissenschaftliche Photographie," 2nd ed., Akademische Verlagsgesellschaft, **1939.**
(2) "Why chemists get fired," *Chemical Industries* **41,** 237, 531 (1937).
(3) CLARKE, *ASTM Bulletin*, No. 108, January, **1941.**
(4) CLARKE, *Ind. Eng. Chem.*, **23,** 1301 (1931).
(5) CLARKE and HERMANCE, *Ind. Eng. Chem., Anal. Ed.*, **7,** 218 (1935).
(6) CLARKE, J. CHEM. EDUC., **14,** 561 (1937).
(7) DUDDING AND JENNETT, *Nature*, **145,** 117 (1940).
(8) EMMETT AND DEWITT, *Ind. Eng. Chem., Anal. Ed.*, **13,** 28 (1941).
(9) "Gmelins Handbuch der anorganischen Chemie," 8th Ed., *Eisen*, System No. 59, F, II, p. 53.
(10) GIBSON, *Instruments*, **9,** 309, 335 (1936).
(11) HANAWALT AND OTHERS, *Ind. Eng. Chem., News Ed.*, **10,** 457 (1938).
(12) HILLEBRAND, *Ind. Eng. Chem.*, **9,** 170 (1917).
(13) HULL, *J. Am. Chem. Soc.*, **41,** 1168 (1919).
(14) JASPER, J. CHEM. EDUC., **14,** 517 (1937).
(15) Editorial in *J. Applied Physics*, **11,** 301 (1940).
(16) LUNDELL, *Ind. Eng. Chem., Anal. Ed.*, **5,** 221 (1933).
(17) RAZIM, J. CHEM. EDUC., **19,** 411 (1942).
(18) RAYLEIGH, *Nature*, **46,** 512 (1892).
(19) RUDGE, *Chemistry and Industry*, **61,** 5 (1942).
(20) VAN BRUNT, *Gen. Electric Rev.*, **39,** 88 (1936).
(21) WEIGERT, *Berichte*, **49,** 1496 (1916).

LETTERS

The Nascent State

To the Editor:

I was glad to see the paper on "The Nascent State" by Reedy and Biggers because this is something that is mentioned in most elementary books on inorganic chemistry. I was brought up to believe in it but during forty-two years of teaching chemistry I have become an agnostic. The difficulty is that most phenomena attributed to the nascent state can be explained better by another hypothesis and this point is not made entirely clear in the carefully written paper by Reedy and Biggers.

The theory of nascent state as applied to such reactions as the reduction of a ferric salt or of arsenious acid by zinc and dilute sulfuric acid is comparable in its stupidity to the theory that when the electric current is passed through a solution of sodium chloride, sodium is liberated but since free sodium cannot exist in aqueous solution it immediately reacts with water to form sodium hydroxide and hydrogen gas. This is still taught in books written today and, to my positive knowledge, is still taught by many teachers in our high schools and academies, although Leblanc showed the absurdity of such an explanation in about 1890. The truth is that anyone at all conversant with the series of oxidation-reduction potentials knows that it is easier to discharge hydrogen from water, or even caustic alkali solutions, than it is to liberate sodium by electrolysis.

In the same way exactly, it is absurd to assume that zinc reacts with hydrogen (or hydronium) ions and the liberated hydrogen will reduce a ferric salt to the ferrous state and an arsenite to arsine. If we amalgamate the zinc, as we do in the Jones reductor, so that it does not react perceptibly with dilute sulfuric acid, it is still efficient in reducing ferric or arsenious ions. Zinc, in other words, is a better reducing agent than is hydrogen gas. The potential series shows this very clearly.

There may be some reactions which can be explained best by the assumption of the nascent state, but of this I am sure: in most reactions attributed to the nascent state the theory is unnecessary and absurd.

Out-dated theories persist in our literature and in our teaching to beginners. In teaching elementary students, as I am now doing after becoming too old to be fitted to continue teaching college students, it seems to me very necessary to avoid such old-fashioned ideas as those that revert to the beginning of the nineteenth century and which modern studies have shown to be unnecessary. I don't care a rap whether the beginner is taught about H_3O^+ ions (as Brown and Columbia Universities wish) but I wish preparatory school teachers would stop talking about the remarkable properties of *nascent* hydrogen or *nascent* chlorine by which the newborn babe can accomplish results that the adult hydrogen cannot hope to do. To be sure it is not as immoral as the way chemical affinity (a sort of free love theory) used to be taught.

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Guide Posts to Successful Teaching[1]

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(*Experiments 1 and 2—Warming up the Lecturer, and Immiscible Liquids*)[2]

TO BEGIN with, let it be said that what follows is intended primarily for the secondary-school teachers of chemistry. Technical experts, professors of college chemistry, and trained workers in the field of research have their own areas from which they may speak. I have no intention of trespassing in their bailiwicks.

(*Experiment 3—Red, White, and Blue*)

One of the first problems which the secondary-school teacher must try to solve is that of developing and maintaining class interest in the subject. "*Interest is the salt that makes the student thirsty.*"

Much of the inattention, indifference, listlessness, disorder, and even breaches of discipline may often be traced to the inability of the teacher so to teach the subject that it shall be both interesting and instructive from the pupil's standpoint. Most of the above untoward conditions will disappear when the subject is well taught. There is a very marked difference between the classroom of the live, alert, enthusiastic teacher and that of the incapable, dull perfunctory instructor.

(*Experiment 4—Spontaneous Ignition*)

Now there are certain guide posts to successful teaching; let us consider a few of them.

1. The teacher must know his subject. But this means much more than many teachers seem to think. It means easy ability to handle the subject, to present it in its most interesting and valuable aspects, to instil into instruction a degree of inspiration, and to awaken in the pupil a desire to learn more. The ideal teacher can do these things and it is toward this goal that all of us may well strive.

But it has been no uncommon experience, in my visits to schools in various parts of this country, to find an instructor sitting at a desk or table with the book open before him, asking questions from it, and referring to the paragraph to make sure that Johnny has answered correctly the question asked. What confidence can a class repose in a teacher who is so obviously wedded to the book and so apparently helpless without it? If there is any dead, uninteresting method of teaching chemistry, that is it! If one does not know his subject well enough so that he can go into his classroom and teach the chemistry of hydrogen, ammonia, carbon dioxide, or what have you, without reference to the text, he has still a long way to go on the road to the top. My advice is to cut loose from the book as much as possible.

This is not to be interpreted as meaning that the book is not to be referred to in the classroom. Of course you must turn to it when assigning tomorrow's lesson; to point out the more important topics in the assignment; to indicate any difficulties that may be encountered; to suggest best methods for study; to call attention to the diagram on page 37 which you want the class to bring in tomorrow done in ink on uniform-size paper. But in general your class should soon arrive at the conclusion that you are not married to that book and could get along very well without it.

(*Experiment 5—Preparation of Fluorescein*)

2. The teacher must know much more than just the immediate subject. Questions are continually being raised in the class; questions suggested by something in a pupil's recitation, or by a statement in the text, or by an item which a student came across in his reading of the daily paper. These questions are often not answered by anything in the text. John wants to know how they get bromine from sea water and what they do with it after they get it; George wants to know what we are going to do for rubber now that the supply from the East Indies is cut off, and what about this synthetic stuff; Henry inquires why Thomas A. Edison was fooling around with golden rod and other plants; Mary is interested in rayon and Alice wants to know what is "this stuff that carries light around corners." Now if you can give the class some account of the Dow Chemical plant at Wilmington, N. C., for the recovery of bromine and the use of bromine in "ethyl-gasoline"; if you can outline some of the still available sources of rubber: the Firestone plantations in Liberia and the Ford plantation in Brazil, and such sources as guayule, cryptostegia, and corn; if you can tell the story of Edison's experiments with latex-producing plants in the hope of finding one that could be developed for large-scale production; if you can tell a little something about the synthetic rubber substitutes such as Thiokol; if you can tell about the production of nylon from coal, air, and water interestingly; if you can show Alice a specimen of Lucite (show sample) and demonstrate how, because of its perfect internal reflection, it can carry light "around corners" (demonstrate this)—you will have won a strong position with your class. It is a wonderful thing if you have been so fortunate, as I have been, to visit some of the great plants where chemistry is applied to industry. Why should not teachers of chemistry receive promotional credit for an extended trip to plants where industrial

[1] Abstract of an address given at the Fourth Summer Conference, N.E.A.C.T., University of New Hampshire, Durham, New Hampshire, August 13, 1942.

[2] The address was punctuated with interest-arousing experiments which were not explained until the curiosity of the audience became overpowering. These are described in detail later.

use is made of the principles of the science which you are teaching? Surely, such an acquaintance at first hand is a most valuable instrument for instructional purposes.

(*Start Experiment 6—Spontaneous Explosion*)

Few of us are Admirable Crichtons who can answer everything which can be asked of us. If you don't know the answer to some question, say so frankly; it is better to do that than to pretend to have knowledge which is not yours. Your pupils may not know the subject any too well but they are pretty good guessers as to whether you know it or not. In a case of this sort it may be well to appoint a few pupils to investigate the question and report at the next meeting; you may indicate to them where they are most likely to find the desired information. You may also add that you will make an effort to learn about the matter under discussion.

3. *The teacher should be resourceful.* Emergencies may often arise from which some escape must be found. Suppose, for example, your laboratory work this morning calls for a solution of lead nitrate. You go to the stock room and find lead oxide and lead carbonate but no lead nitrate. Well, what are you going to do? Shall you telephone the purchasing agent to order a supply and then defer that experiment until the material arrives? Nonsense! In five minutes you can have a supply of lead nitrate solution that will answer present needs. Let's do it!

(*Experiment 7—Preparation of Lead Nitrate and Lead Iodide*)

Here we have some warm dilute nitric acid to which I add small portions of litharge, PbO, as long as it continues to dissolve. The supernatant liquid is now poured into another tube and a little potassium iodide solution added; the beautiful yellow lead iodide proves that we had a soluble lead salt.

Now, there are many chemicals common to a school laboratory which any teacher can prepare. It is easy to produce mercurous nitrate from mercury; corrosive sublimate from mercuric oxide; sodium nitrite from sodium nitrate; antimony trichloride from stibnite; barium chloride from witherite; silver nitrate from a dime; copper chloride from copper sulfate through the carbonate; potassium permanganate from manganese dioxide; potassium dichromate from green chromium oxide; sodium arsenite from white arsenic; and dozens of others. Many of these are so easily and quickly done that you may be able to turn some preparations over to a bright student, with instructions, of course. Suppose, for instance, you need some mercuric chloride, given mercuric oxide:

(*Experiment 8*)

Into some dilute hydrochloric acid, I introduce small amounts of the oxide until no more reacts. The clear liquid is poured off into another tube and tested by addition of a solution of potassium iodide; the scarlet product shows that we had a soluble mercury salt. When this product is poured back into the potassium iodide solution, the solid disappears due to the formation of a soluble complex salt, $K_2(HgI_4)$. Addition of mercuric chloride solution restores the product.

It would be a fine thing if every teacher of chemistry could have had a course in inorganic preparations, but if you have never had such a course, you can nevertheless teach yourself. Half an hour a day twice a week devoted to laboratory work for the school year will put into your hands a great deal of usable material. Good books for such work are available, such as Blanchard and Phelan, "Synthetic inorganic chemistry," and Henderson and Fernelius, "Inorganic preparations."

(*Experiment 9—Cupromercuric iodide*)

4. *The teacher may well encourage the investigative spirit among his pupils.* We may call this "research for beginners." Suppose Ellen has recited that Priestley heated red ash of mercury and got mercury and oxygen. This suggests the question, "Do the other simple oxides of the metals also yield oxygen when heated?" The book says nothing about that. Suppose now you ask Tom what would happen if copper oxide were heated. Tom doesn't know but, following the suggestion in Ellen's recitation, thinks maybe you would get copper and oxygen. Without commenting on this, you ask Bill what would happen if lead oxide were heated. Since you did not turn down Tom's statement, Bill is encouraged to say that you would probably get lead and oxygen. Sarah is quite sure that iron oxide would yield iron and oxygen, and Walter is positive that magnesium oxide would produce magnesium and oxygen if heated. They are not furnishing evidence of thought but are following the line of least resistance and are like sheep going over a wall, each one following the one ahead. Now suppose you call to the desk two or three of those whose statements have been wrong and let each one heat his particular oxide, applying the splint test for any oxygen that may escape. In about five minutes three disgusted youngsters lay three red-hot test tubes down on the asbestos mats provided and return silently to their seats. Now you haven't told them one thing but the whole class has seen the investigation and should have reached the conclusion that the simple oxides of the metals do *not* always yield oxygen when heated. You could have told them this in less time than the investigation has taken, but you would have lost the opportunity to develop their observational powers and the ability to reason from observed phenomena to a good conclusion, which is one of the foundations of good teaching.

But now up goes Walter's hand. "How come that mercury oxide acts that way when the others don't?" Good question, but don't answer it—not yet. Instead call Walter to the desk and let him point out the location of mercury in the displacement series, well down toward the bottom. A little questioning will bring out the fact that a silver dime doesn't oxidize even if heated; that gold rings do not oxidize either; and you can show that platinum foil when heated red-hot does not form an oxide. Presently some bright youngster is going to exclaim: "I guess the metals at the bottom of the list are not very hungry for oxygen

and don't hold onto it very strongly when they do have it!" Good! And our recent experiment with heating other oxides shows that as we rise in the displacement series the difficulty of separating the oxygen from the metal increases. So, without telling them anything you have brought them to the desired point by experiment, observation, and reasoning. In this connection it may be remarked that the displacement series may well be introduced much earlier than is usual; it is useful in a number of ways.

(*Experiment 10—Capillarity*)

In general, it may be said that many teachers do too much telling; they mistake *telling* for *teaching*. It is better to draw out of a pupil the knowledge he has and to build upon it by good Socratic questioning, to develop a new point of view or a new area of knowledge, than it is to proceed in a manner that calls for little mental activity on the student's part. Learning takes longer by this process, but the results are worth the time. We are too much inclined to regard our pupils as memory machines rather than as thinking machines. Certain fundamental facts to be remembered are necessary and to these new material is added daily, but the more important thing is to teach the pupil to think, to observe, to reason from the known to the unknown.

There are times, of course, when the lecture or telling method seems the only way to present topics which are too theoretical for the pupil to grasp otherwise, or which are incapable of demonstration, topics which no amount of adroit questioning could draw forth from a pupil.

5. *The teacher must be adept in the art of demonstration.* No method has yet been devised which is superior to the well-conducted experiment at the teacher's desk. The instructor must be able to set up and operate apparatus in a neat and workmanlike manner. He will see that everything needful is at hand, that all glass is wiped off so as to appear bright and attractive, and that the whole experiment is conducted in the most interesting manner. But performed simply as an experiment, the demonstration falls far short of its full effect; it is only completely effective when it is accompanied or followed by exhaustive questioning to make sure the class has seen and understood what substances were used and the properties of each; what was the function of each; what precautions, if any, were made and why; what chemical changes took place; what were the final products and how each might be identified; how any by-products may be recovered. Following all this, an average pupil should be able to give you a pretty good résumé of the experiment.

(*Experiment 11—Dyeing with Indigo*)

I have been much surprised, however, to find how many teachers in different parts of this country are making little or no use of the demonstration. To me it is one of the most valuable means of instruction.

Time does not permit an extended demonstration here, but let us suppose we are considering the question of oxidation and reduction with its accompanying changes in valence due to electron transfer.

(*Experiment 12*)

Here we have a solution of potassium permanganate. It is easy to demonstrate that the potassium ion is colorless, hence we must conclude that the color here is due to the MnO_4^- ion. Now we pour the colored liquid slowly into a concentrated solution of sodium bisulfite (or sulfurous acid). A remarkable change occurs; the class is now interested and will grasp the explanation more readily.

Now let us have something really interesting. Four short demonstrations by expert teachers follow.

First: *Experiment 13. Conductivity of Fused Electrolytes.* Mr. Elwin Damon, Keene High School.

Next: *Experiment 14. Explosive Mixtures.* Mr. Benjamin Graves, So. Portland High School.

Then, *Experiment 15. Solid Alcohol.* Mr. Theodore Sargent, Swamp-Scott High School.

Experiment 16. Electrolysis of Potassium Chloride. Miss Clara McDonald, Nasson College.

Now we have another oxidation-reduction experiment.

(*Experiment 17*)

Here are 50 ml. each of very dilute solutions of potassium iodate and sulfurous acid to each of which a little starch paste has been added. The potassium iodate can be made by any bright student in a high-school laboratory. Now on the even second (Has anybody got a watch?) the two solutions are poured at the same time into a larger graduate and well shaken. Watch! You see what happened. What was the elapsed time?

6. *The tactful teacher will show proper appreciation for special work of excellence done by interested students.* If John has made some nice drawings, like these, show them to the class and display them in the showcase in the corridor. If Sarah has been interested to undertake some color work in plaster of Paris, show that and let Sarah tell how it was done. If Bertha has done a creditable piece of glass etching, display it. You know young people like a little praise, and there have been older ones who are not averse to an occasional pat on the back.

7. *The progressive teacher will have a small arsenal of projects for the occasional use of the able and interested student.* Such projects should be interesting, different, not difficult nor too long, and free from danger. They should always result in some tangible product. It doesn't satisfy Arthur to be told, "Oh, just take another experiment in the manual!" when he asks for something special to do. One trouble with most of the manual experiments is that they provide nothing tangible as a result of an experiment. When Joe has finished his experiment with zinc and sulfuric acid, what has he to show that is tangible? He might have specimens of both the anhydrous and the crystallized zinc sulfate. But few manuals pay much attention to the recovery of the by-products of an experiment. He could recover potassium chloride and manganese dioxide from oxygen experiment, calcium chloride from carbon di-

oxide experiment, and beautifully crystallized lead nitrate from the experiment for making lead peroxide.

Now there are many suitable and attractive subjects for project work. Here are some simple dyes and their application to wool; here some lettering on glass (time about five minutes); here a pigment; here ink, sprays, lakes, half a dozen easily made. Lead compounds, mostly colored; copper compounds, all colored; crystals of various shapes and colors; guncotton and picric acid; acetanilide; various other products; and finally some amyl nitrite which if inhaled will make the most hardened sinner blush.

Now every one of these projects offers something definitely tangible; something attractive; something which the student can take home and show to the family and friends, and explain: "Lookit! See what I made in Mr. Bonehead's class!"

As an example of how little time some of these projects take, let us prepare Orange II.
(*Experiment 18*)

8. The good teacher will recognize the values that lie in:

(*a*) *Drawings.* Drawing is a universal language. Every student should be required to reproduce in ink on standard-size paper about fifteen of the line drawings shown in the text such as: Lavoisier's apparatus, the distillation of water, the apparatus used for preparation of oxygen, hydrogen, carbon dioxide, and other gases. No special artistic talent is needed, only a pen, ruler and compasses.

(*b*) *Models*, particularly the working model. Here is a model of a stampmill such as you may see all through the mining states. The heavy weights falling on the chunks of ore reduce them to any desired size. This model of a fire-door is a good project for a small group of students. George makes the fusible alloy, a narrow strip of which holds the door back; Patrick makes the woodwork; Henry makes the little figures out of clothespins; and Emily makes the little garments. The link will melt if steam or boiling water is directed against it and then the door closes of itself.

A working model of a storage battery is easily possible; others will suggest themselves to the energetic teacher ready to seize on a new idea.

(*c*) *Exhibits.* Some pupils may be interested to do real glass etching, not of the perfunctory type found in the manuals. And there are any number of live interesting subjects on which better students may expend interest and energy in producing something different.

(*d*) *New applications.* A natural question which a pupil may ask is: "Now I have this substance prepared, what practical use can I make of it?" Well, you can set George to work to convert a hot oil into a solid fat by passing dry hydrogen into the hot oil with finely divided nickel as a catalyst.[3] The use of oxygen as an agent in the dyeing with indigo on cotton is another example. Charcoal, prepared by heating wood cubes under sand, can be shown to be an excellent adsorbent for ammonia and other gases, which, of course, suggests its use in gas masks.

[3] J. CHEM. EDUC., **8**, 1856 (1931).

(*e*) *The use of pictures, clippings, and articles.* A series of related pictures, say of the iron industry, can be mounted on cards and displayed in the corridor showcase, an interesting project for some pupil.
(*Experiments 19 and 20. Fire Foam and Graham's Law*)

9. The teacher will call upon the student for aid. It is often a good plan to call to the desk a pupil to assist you in a demonstration, going easily with them at first and gradually increasing your demand as their skill and confidence increase. The purposes of this are:

(*a*) To introduce variety into the classroom routine.
(*b*) To stimulate interest by this variety.
(*c*) To accustom students to appear before small audiences. In time they may develop confidence and skill enough to give five-minute talks on some simple subject with an illustrative experiment or two.

10. The efficient teacher will stress the fundamental principle underlying a given reaction and those related to it. For example:

The general effect of heat on simple oxides and carbonates.
The fundamental principle underlying the preparation of ammonia gas.
The general principle for the preparation of chlorine.
The principle of insolubility in the preparation of various products.

I close with this experiment. A white wool skein is removed from a colorless liquid and introduced into another colorless liquid; the skein turns blue!
(*Experiment 21*)

EXPERIMENTS ACCOMPANYING THE LECTURE

1. Warming up the Lecturer

Light the gas. When the match-head chemicals have burned off, thrust the blazing wood into the mouth and close the lips; you won't get burned. Wash your hands with quick action in the Bunsen flame; you won't get burned.

2. Immiscible Liquids

Dissolve a small speck of Oil Red or other oil-soluble dye in 10 ml. carbon disulfide. Dissolve a speck of some water-soluble dye of another color in 10 ml. water. Pour the two liquids into a large test tube and cork tightly. Shake as much as you please, the liquids will quickly separate, each carrying its own color.

3. Red, White, and Blue

Prepare 50 ml. solutions of: (*a*) potassium thiocyanate, (*b*) barium chloride, (*c*) potassium ferrocyanide. Pour into each some ferric ammonium sulfate solution. If the colors in (*a*) and (*c*) are too dark dilute the original solutions to proper strength.

4. Spontaneous Ignition

Dissolve a piece of dry yellow phosphorus the size of a pea in 10 to 15 ml. carbon disulfide. Keep in a tightly stoppered bottle in a safe place. DANGEROUS. With a medicine dropper deposit a few drops in the center of a dry filter paper laid across the top of a beaker or wide-mouth bottle.

5. Preparation of Fluorescein

Mix 0.2 g. of phthalic anhydride with 0.5 g. of resorcinol and add one drop of concentrated sulfuric acid. Heat the tube gently and dissolve the product in dilute sodium hydroxide solution. What color is the solution by (*a*) reflected, and (*b*) transmitted light?

6. Spontaneous Explosion

Drop a little of the phosphorus solution onto a gram of finely powdered potassium chlorate in a small dish. Wait. Or use a potassium chlorate tablet and tap it with a long stick.

7. Lead Nitrate

Add to 10-ml. warm dilute nitric acid small amounts of litharge, PbO, until it ceases to react. Let it settle. Pour the clear liquid into a graduate, add equal amount of water, and test with KI solution.

8. Mercuric Chloride

Add small amounts of mercuric oxide to 10 ml. warm dilute HCl until there is no reaction. Let settle. Pour the clear liquid into a graduate and add slowly some KI solution. Be careful not to add too much. Finally pour the scarlet precipitate into 10 ml. KI solution. The color disappears. Add mercuric chloride solution until the precipitate returns.

9. Cupromercuric Iodide

Dissolve 6.8 g. mercuric chloride in 50 ml. water. Dissolve 18.3 g. potassium iodide in 100 ml. water. Pour exactly half of this into the mercuric chloride. Let settle. Pour off as much as possible of the supernatant liquid and add the rest of the KI solution to the scarlet residue; it will dissolve. Now add 12 g. copper sulfate dissolved in as little water as possible. Saturate the whole with SO_2. Filter off and dry the solid red product. When perfectly dry, powder it and introduce some of the powder into a number of 6-mm. tubes sealed at one end and about 6 to 8 in. long. The red powder turns black at temperatures above 75°C., and becomes red again on cooling.

10. Capillarity

Dye a narrow long strip of cotton cloth in a dye bath of Congo red to which a drop of sodium carbonate has been added. Dye another strip in methyl orange to which a drop or two of sodium carbonate has been added. Let both strips dry. When dry, suspend the strips side by side so that their lower ends just dip into some dilute hydrochloric acid. As the acid climbs up the strips, due to capillary action, they change from red to blue and from yellow to pink.

11. Dyeing with Indigo

Before the lecture, prepare a square of cotton cloth of any desired size and attach a 12-in. string to each of two adjacent corners. Soak the cloth in water. In a flask dissolve about one-fourth of a gram of Indigotine (soluble indigo) in 50 ml. hot water and decolorize by cautious addition of "sodium hydrosulfite," $Na_2S_2O_4$, as little as possible; add a few drops of sodium hydroxide solution. Immerse the wet cloth in the dye, letting the two strings hang outside. Pour a little oil (kerosene, cottonseed, or other light oil) into the flask to form a cover to keep air away. To carry out the demonstration, heat nearly to boiling for five minutes. Pour off the oil and water, withdraw the cloth by the two strings and suspend the cloth on a horizontal bar. The air will oxidize the leuco-indigo back to blue indigo.

12. Oxidation and Reduction

Pour a moderately strong solution of potassium permanganate (one g. per liter) into a strong solution of sodium bisulfite (or sulfurous acid). The color is destroyed.

13. Conductivity of Fused Electrolytes

The terminals of an electric circuit (110 volts) rest in powdered potassium nitrate in a small dish. No current flows. Heat the dish until the nitrate melts; the current flows. Let stand until the melt begins to solidify.

14. Explosive Mixtures

Procure a tin can with round cover that presses in. Malted milk cans are good. In the center of the cover punch a small hole and near the botton of the can make a hole in the side large enough to admit a piece of 6-mm. tubing. Put on the cover and insert in the lower hole one arm of a glass bend, the other end being connected to the gas cock. Turn on the gas and light it at the hole in the top. Then withdraw the glass tube and turn off the gas. After a time, when just the right proportion of gas and air is reached, the cover (if pressed firmly in) will be blown to the ceiling. Coal gas is most effective.

15. Solid Alcohol

Take three ml. of a *saturated* solution of calcium acetate and about eight to ten ml. of 95% alcohol to which a little solid dyestuff has been added. Pour the two solutions at the same time into a small beaker or evaporating dish. The exact amount of alcohol must be determined by trial and the calcium acetate solution *must* be saturated. Cut out some of the gel and place on base of ring-stand; ignite it.

16. Electrolysis of KCl

A U-tube with side arms is filled with a solution of KCl to which a little phenolphthalein has been added. On the anode side a tube leads from the side arm to another tube containing a solution of KI and starch paste. Two long nails passing through tight-fitting one-hole rubber stoppers serve as the electrodes. When the current from about three dry cells in series passes through the solution, the cathode side turns red. On the anode side it takes some time for the liquid to be saturated with chlorine but presently this gas will pass down to the lower tube where the starch paste will be turned blue.

17. "Wink Experiment"

Dissolve one g. of potassium iodate in 500 ml. water (Solution A). Saturate 10 ml. cold water with SO_2 and dilute to 500 ml. (Solution B). Take equal volumes of A and B to each of which a few drops of starch paste have been stirred in, using different stirrer for each and pour into a larger graduate and stir or shake well. In about 20 seconds the reaction occurs.

18. Orange II Dye

Dissolve one g. sulfanilic acid in as little dilute sodium hydroxide solution as possible. Add a gram or two of sodium nitrite and stir; acidify with dilute hydrochloric acid. Pour into a solution of beta naphthol dissolved in as little dilute sodium hydroxide solution as possible; stir well and let stand overnight. Then filter off the dye, dry, powder, sift through cheesecloth and preserve. It dyes wool.

19. Fire Foam

Dissolve one g. powdered glue and 10 g. sodium bicarbonate in 100 ml. water (Solution A). Dissolve one g. glue and 10 g. aluminum sulfate in 100 ml. water. Equal volumes of these solutions poured into a tall graduate or hydrometer jar will yield a column of froth. If possible to obtain the real materials from some dealer in fire protection supplies, the results are much better.

20. Graham's Law

Pass hydrogen gas up into a beaker inverted over a porous cup sealed to a tube leading down into a two-necked Wulff bottle; the second neck carries a tube drawn out to a fine jet. The Wulff bottle is full of colored water. The water squirts out of the jet.

21. Colorless Dyeing (apparently)

Make a solution of about one-fourth of a gram of Alkali Blue or Nicholson's Blue in 50 ml. of water; decolorize by addition of sodium carbonate, not too much. Wet a small skein of white wool in water and lower into the colorless liquid by means of a string. Bring to a boil. Draw up the skein by the string, drain and squeeze, and suspend in a graduate containing water and a few drops of sodium carbonate solution. Now prepare a hydrometer jar or tall graduate with a solution of dilute hydrochloric acid in water. Draw up the skein, squeeze out as much as possible of the liquid which it carries, and lower the skein slowly into the very dilute acid. The blue color will develop.

Report of the NEW ENGLAND ASSOCIATION *of* CHEMISTRY TEACHERS

OFFICIAL BUSINESS

217th Meeting—October 10, 1942
Technical High School
Springfield, Massachusetts

THE MORNING program consisted of two addresses—one, "The Structure of Cadinine," by Professor Milton B. Soffer, Smith College, and the other, "Developments in the Teaching of Analytical Chemistry," by Professor Lucy W. Pickett, Mount Holyoke College. In the afternoon, Professor David C. Grahame, Amherst College, spoke on "The Nature of the Electric Double Layer." The meeting was followed by an industrial trip to the Sewage Disposal Plant of the City of Springfield.

Just prior to the luncheon at the Sheraton Hotel in Springfield, a short business meeting was held with President Theodore C. Sargent presiding. The Necrology Committee presented a resolution on the death of Professor Hoover of Wesleyan University, who was killed in a collision of two "blimps" off the New Jersey coast in June while working on a secret assignment for the government. Dr. Hoover joined the NEACT in 1921 and was a member of the committee which organized the Western Division of the Association, of which he was chairman from 1924 to 1926. He was always active in his support of the Association and spoke before it on many occasions, the last being the Second Summer Conference in 1940 at the University of Maine.

The following resolution was adopted:

Remembering Dr. Charles Ruglas Hoover, a member of our Association, as one who preferred to serve rather than to be served, we can understand the circumstances of his passing to the great Beyond.

We recall him as an earnest worker in his profession, as a member who willingly responded with his time and labor to help in furthering the advancement of Chemistry, and as a genial and steadfast friend to all of his associates.

Realizing the loss we have suffered, and appreciating his worth, be it

Resolved: by the New England Association of Chemistry Teachers in meeting assembled, that we deplore the untimely passing of Dr. Hoover; that his memory will always be a bright spot in our lives; and that his absence from our meetings and professional intercourse will be a distinct loss to each one individually and to our Association as a whole.

As a matter of permanent record, *be it further Resolved:* that these resolutions be made a part of our minutes; that a copy be sent to his bereaved family and that they be printed in our official publication.

Respectfully submitted, ELWIN DAMON

Secretary Neal announced for the Membership Committee the election of the following to *active membership:*

Dr. Pedro Vasquez Lopez, Professor of Chemistry, La Progresiva College, Cardenas, Cuba.
Dr. Paul L. Lovett-Jamison, Chemistry Teacher, Taft School, Watertown, Connecticut.
Rev. Gerald F. Hutchinson, S.J., Cheverus High School, Portland, Maine.
Rev. Bernard A. Fiekers, S.J., Chairman of the Department of Chemistry, Holy Cross College, Worcester, Massachusetts.
Mr. H. Benjamin Hendler, Bulkeley High School, Hartford, Connecticut.

The secretary also announced that the following had been placed upon the *deferred list of members:*

Ensign Paul J. Boylan, U. S. N. R., Prince George Hotel, New York.
Lt. Wilton Brown, U. S. Naval Training School (Navigation), Coral Gables, Florida.

CHARLES RUGLAS HOOVER
1885–1942

Ensign Louis I. Kramer, U. S. N. R., Norwich, Connecticut.
Pvt. Laurence E. Bohrer, Hq. Btry, 315th F. A. Bn., Camp Forest, Tennessee.
Lt. (2nd) Robert C. Chandler, Army Air Corps, Instructor in Mathematics. (address not available)
Ensign Ernest H. Valley, Naval Air Training Service, Corpus Christi, Texas.
Richard I. Savage, Co. C. 3rd Bn. O. R. T. C., Aberdeen Proving Grounds, Maryland.
Pvt. Edgar A. Moberg, School Squadron, Barracks 200, Chanute Field, Rantoul, Illinois.

Miss Hamilton, Treasurer of the Association, wishes to call to the attention of the members the necessity of payment of dues before January 1. The subscription list for the JOURNAL OF CHEMICAL EDUCATION must be complete on that date.

1942–1943 SCHEDULE

The executive committee announces that meeting places have been arranged for the following meetings:

218th Meeting, December 5, 1942, Simmons College, Boston, Massachusetts.
219th Meeting, February 6, 1943, Moses Brown School, Providence, Rhode Island.
220th Meeting, March 6, 1943, Hillyer Junior College, Hartford, Connecticut.
221st Meeting, April 3, 1943, Phillips Exeter Academy, Exeter, New Hampshire.
222nd Meeting, May 15, 1943, Tufts College, Medford, Massachusetts (Annual Meeting)

MODERN METHODS OF SOIL TESTING*

G. P. PERCIVAL
University of New Hampshire, Durham, New Hampshire

Various methods have been used to analyze soil, such as analyzing the ash of plants to see what they remove from the soil, boiling the soil with hydrochloric acid and testing the filtrate, and fusing with sodium carbonate to determine the total amount of the constituents present. Greenhouse methods have been worked out whereby both major and minor elements[1] may be determined both as to their deficiencies and toxicity levels. These include pot or bench tests, using the actual soil, and measuring growth response and keeping record of any abnormal symptoms that appear as well as analyzing the crop. Boron deficiency has been determined by the method of Colwell and Baker.[2] We planted five sunflowers in one pound of soil in a number one R enameled can, force-fed the plants with a nutrient solution, and measured the time elapsed before boron deficiency appeared at the growing tip as compared with a corresponding time for plants growing in a check soil. Sand and water cultures have been used to bring out deficiency symptoms in various plants and the effect of an excessive application of minor elements can be determined both in sand and pot cultures.

In recent years there has been a great increase in the interest in the "quick tests," or tests for available nutrients. These methods usually consist of extracting a sample of soil and determining the amount of the elements in question present in the clear extract. However, one of the most important requirements is a good sample of the soil itself. If it does not represent the area in question, the results are of little value. The sample should be a well-mixed composite of numerous uniform soil slices taken by a trowel or spade or borings 6 to 8 inches deep from a field that is to be plowed, or 2 to 4 inches deep from pastures and lawns that are to remain in sod. To measure penetration of fertilizer, a soil tube can be used to remove a core of soil, which is divided into sections, and the amount of available nutrients at various levels is then determined. It is essential to use clean equipment not contaminated with chemicals or fertilizer. The extracting solutions vary from the dilute (0.25 *N*) acetic acid of Spurway[3] to the solutions of strong acids, such as 0.3 *N* hydrochloric acid of Baver and Bruner.[4] We use the solution as proposed by Morgan,[5] 0.05 *N* acetic acid buffered at a pH of 4.8 with sodium acetate. The solution is not affected by limed soils and has a pH value approximately that of the soil solution around a root hair. Our procedure is the same as Morgan's, with the exception that the soil is placed in a vial with the extracting solution and shaken mechanically for one minute before filtering. We determine the pH value of the soil by the use of a Beckman pH meter. This can also be done colorimetrically, as with the Morgan pH set.

The results of the tests are reported either as ratings, very low to very high, in pounds per acre, or in relative test index of 1 to 10. The interpretation of the soil test is important, and various factors have to be taken into consideration such as the crop to be grown, soil condition, and plant diseases. Recommendations are based on results from experimental fields of known yields and treatments.

The bulletin by Morgan gives the methods of testing soils in considerable detail, together with color charts for estimating the quantities of eight important soil components. It is recommended to teachers who wish to bring this subject to the attention of their students.

* An abstract of an address given at the Fourth Summer Conference of the New England Association of Chemistry Teachers, The University of New Hampshire, Durham, New Hampshire, August 12, 1942.

[1] BROWN, "The present status of minor elements in plant nutrition," *Report of the New England Association of Chemistry Teachers*, **43**, 176 (May, 1942).

[2] COLWELL AND BAKER, "Studies of boron deficiency in Idaho soils," *J. Am. Soc. Agron.*, **31** (6), 503–12 (June, 1939).

[3] SPURWAY, "Soil testing: a practical system of soil diagnosis," *Mich. Agr. Expt. Sta. Tech. Bull.*, **132** (1933).

[4] BAVER AND BRUNER, "Rapid soil tests for estimating the fertility needs of Missouri soils," *Mo. Agr. Expt. Sta. Bull.*, **404** (1939).

[5] MORGAN, "Chemical soil diagnosis by the universal soil testing system," *Conn. Agr. Expt. Sta. Bull.*, New Haven, Conn., **450** (Oct., 1941).

RECENT BOOKS

PHYSICAL SCIENCE. *W. F. Ehret*, Professor of Chemistry, Editor; *L. E. Spock, Jr.*, Associate Professor of Geology; *W. A. Schneider*, Associate Professor of Physics; *C. W. van der Merwe*, Professor of Physics; *H. E. Wahlret*, Instructor in Mathematics, Collaborator, New York University. First Edition. The Macmillan Company, New York City, 1942. x + 639 pp. 295 figs., 28 tables. 15 × 23 cm. $3.90.

The main purposes of the book are clearly described, "to provide a broad background of knowledge of the physical sciences which is essential to the culture of an educated man if he is to appreciate the world of today, and to provide some understanding of the scientific method and the necessity for its use to attain clear, logical, unbiased, and accurate thought in any field of human endeavor, as well as in science. We shall consider the basic concepts of astronomy, chemistry, geology, and physics, and some of the ways in which these subjects are interrelated. The use of mathematics as a guiding principle and also as a tool will be made clear."

The reviewers share the conviction that the accomplishment of these purposes should be within the ambition of modern education. The major problem in a textbook or a course of study is always the choice in emphasis between subject matter on the one hand and, on the other, the spirit and methods of science. A second, almost equally significant dilemma, is the choice between focus on established fields of study and diffusion on the essential unity of science.

The resolutions of these choices, as represented in this book, make it the best introductory textbook in physical science that has come to the attention of the reviewers. The choice of the subject matter in the various fields is discriminating and well integrated, the treatment is professionally sound, clear, logical, and as rigorous as is consistent with the elementary treatment with a few exceptions which will be mentioned later. There are plenty of well-drafted and well-chosen figures, exercises, and problems, and some, though not enough perhaps, illustrative examples worked out in detail. The references at the end of each chapter are well selected. The value of the book might be improved by the use of a larger number of pictures of physical scientists than the four given in the book.

The chapter on The Scientific Method has good discussions of the role of observation in science and of the nature of inductive and deductive reasoning. Later chapters on Science and Measurement, Discovering Scientific Laws, and the Nature of Scientific Reasoning present a good picture of the way the scientist works and thinks. The method of science should appear from this more clearly than from the discussion in most elementary textbooks. One might quarrel with some aspects of it; for example, the role of assumptions and laws are discussed in the last chapter of the book. Here the postulates of Dalton's atomic theory are called "fundamental laws" in the same sense as are Newton's laws of motion.

There are places where one could wish the authors had dealt a little differently with a particular subject. The statement about significant figures near the bottom of page 13 is usable but very cumbersome. On the other hand, the statement—"When this measured quantity is used in calculations, the results are also expressed in a manner which implies no greater accuracy than is inherent in the original measurement, that is to say, the calculated result will be expressed to three significant figures"—is not rigorous in that the last clause is valid only if the calculated result is obtained by multiplication or division; it is not valid for addition and subtraction. Also the statement of Newton's second law of motion can give a false impression: "The measure of the force which has acted on an object to alter the state of its motion is the product of the object's mass by the acceleration produced." This can lead a student to the conception that a force has to act for a considerable time to produce the acceleration. The acceleration exists while the force is acting and not after it "has acted."

The discussion of the second law of thermodynamics is good. Many elementary textbooks avoid dealing with it because of its difficulty but that is an evasion that does not seem justifiable when we consider that the second law and the laws of conservation of mass and energy are the most generally applicable laws that have been stated in physical science.

While the authors have correlated the various fields of physical science surprisingly well, there are still instances where the correlation could be much improved; for example, in the discussion of cosmogony, the authors are content with purely descriptive material of the universe outside the solar system and raise the question of origin only in respect to the solar system. The grand perspective of time and evolution—one of the principal lessons of the physical sciences—could have been emphasized by relating earth-origin hypotheses to the studies of extragalactic nebular evolution and the ideas of stellar evolution. Although these studies are in a highly inconclusive state, that is equally true of the current speculation on the evolution of the solar system.

One hundred and fifty-four pages of the book are devoted to strictly chemical subjects. The chapter headings include: Chemical Changes, Oxygen and Hydrogen, Water and Solutions, Chemical Equilibrium, the Periodic Classification, Metals and Metallurgy, Salt and Limestone, Heavy Chemicals, and Compounds of Carbon.

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X-RAY CRYSTALLOGRAPHY. *M. J. Buerger*, Associate Professor of Mineralogy and Crystallography, Massachusetts Institute of Technology. First Edition. John Wiley and Sons, Inc., New York, 1942. xxii + 531 pp. 252 figs. 15 × 23 cm. $6.50.

This book is written primarily for those wishing to determine crystal structures, using single crystals and monochromatic x-rays. For such people, the reviewer recommends it very highly. Experimental methods and the pertinent theory are clearly and accurately described in considerable detail. Related fields, such as x-ray physics, crystal symmetry theory, the results of crystal structure analysis, and crystal chemistry, are (quite properly) entirely omitted from consideration. Obviously, the book is not of much interest to those not actually working—or about to start work—in the field with which it deals.

The publishers, like the author, are to be commended for doing an excellent job.

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ISOMERIZATION OF PURE HYDROCARBONS. *Gustav Egloff, George Hulla,* and *V. I. Komarewsky*, Universal Oil Products Co. Research Laboratories and Illinois Institute of Technology. A. C. S. Monograph Series. Reinhold Publishing Corp., New York, 1942. 499 pp. 15 figs. 15 × 23 cm. $9.00.

Isomerization of hydrocarbons is becoming more and more important in the war effort. The alkylation process, which is the mainstay of our 100 octane gasoline production, requires large amounts of isobutane. To meet the demand, a commercial process for producing isobutane by isomerizing *n*-butane has been developed. In addition, many of the naturally occurring hydrocarbons present in gasoline have low octane numbers, which can be increased by isomerizing them to more highly branched hydrocarbons. Olefin isomerization may become important in producing raw materials for synthetic rubber production.

The authors of this volume have naturally emphasized the application of isomerization to the petroleum industry. The scope of the work is much broader, however, and they have

covered the literature on the entire field of hydrocarbon isomerization. The book should be of interest not only to technologists but also to the organic chemist, since isomerization is one of the important types of hydrocarbon reactions and is a useful tool in organic syntheses.

The authors have done an excellent job in organizing and presenting a great mass of data, culled from some 700 literature articles and patents. They have successfully avoided an encyclopedic treatment of the data, and produced a book which is readable. The subject matter is classified by groups of hydrocarbons, and covers the paraffins, olefins, acetylenes, cycloparaffins, cycloolefins, and aromatics. Each class of hydrocarbon is further broken down into subclasses, so that information on any particular compound or group is readily accessible.

Most of the chapters are opened with a discussion of reaction mechanism; "since there is no general theory of isomerization, a specific theory is required for almost every type of change encountered in hydrocarbon isomerizations. Only those explanations which adapt themselves readily and unequivocally are retained herein and applied to the various hydrocarbon isomerizations." Obviously, the theories or explanations, while they are interesting and sometimes ingenious, add little to our understanding of isomerization.

A particularly useful feature of the book is the table of isomerization data, occupying nearly 200 pages. "The available experimental data have been calculated to a uniform basis wherever possible . . . for the purpose of comparing catalyst concentration, time, temperature, pressure, and yield of products for more than 1700 experiments."

An appendix brings the data up to February 1, 1942. This appendix also includes a digest of the most important patents, classified by compounds isomerized and by catalysts.

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VOLUMETRIC ANALYSIS, Vol. I. *I. M. Kolthoff*, University of Minnesota, and *V. A. Stenger*, Dow Chemical Company. Second Revised Edition. Interscience Publishers, Inc., New York, 1942. xv + 309 pp. 31 figs. 15 × 23 cm. $4.50.

This is the first volume of a new edition of this comprehensive treatise on Volumetric Analysis; earlier editions appeared first in German and later in English translation. The second volume is stated by the publishers to be in preparation.

The general character of Volume I of the new edition is like that of preceding editions since it deals with the fundamentals of the theory of volumetric analysis. The authors have managed to allow this edition to increase only twenty pages over the extent of the translation. This apparent lack of expansion is misleading since a chapter on the stability of solutions has been transferred to appropriate spots in the second volume and many other condensations have been made to allow for the introduction of new material.

A brief chapter, I, on introductory matters has been added. The next three chapters, II, III, and IV cover Neutralizations and Combinations of Ions, Curves for these reactions, and Oxidation-Reduction Reactions in much the same fashion as the earlier editions, but with modernization and with fresh illustrative material in a number of cases. Chapter V on Indicators has been almost doubled (increased from 33 to 54 pages), the increase being accounted for largely by a very thorough review (35 pp.) of oxidation-reduction indicators. Chapter VI on Titration Error is little changed. Chapter VII on Catalysis and Induced Reactions has been considerably revised. Much new material, especially on coprecipitation and mix-crystal formation has been added to Chapter VIII on Adsorption and Coprecipitation Phenomena. Chapter IX on Volumetric Methods of Organic Analysis has been revised. The chief novelty in Chapter X on Methods for the Determination of the Equivalence-Point is a section on Polarimetric or Amperometric Titrations. A two-page section on Activity Constants and Concentration Constants has been added to the Appendix which has also useful tables on Ionization Constants, Solubility Products and Complex-Dissociation Constants.

The authors have made a thorough and competent revision, and the publishers have produced an attractive volume that is easy to read. A moderate amount of fine print has been used to good advantage.

The volume can be recommended to students and teachers as the best existing source of information on the fundamentals of titration methods.

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NUTRITION AND CHEMICAL GROWTH IN CHILDHOOD. Volume I. EVALUATION. *Icie G. Macy*, Ph.D., Director of the Research Laboratory of the Children's Fund of Michigan. First Edition. Charles C. Thomas, Springfield, Ill., 1942. xxiv + 432 pp. 66 figs. 15 × 23 cm. $5.00 postpaid.

A recent lecture by Dr. Anton J. Carlson posed the question: "The newer knowledge of nutrition—how much of it is knowledge?" Dr. Macy's book gives an answer that should bring reassurance to the critics of "the science of nutrition."

This volume, the first of two (the second will be called "Interpretation") reports the results of a ten-year investigation by Dr. Macy and her collaborators to establish standards of growth and development for the normal child. Although the chief interest of the group has been centered in biochemical determinations, the data include "pediatric, anatomic, psychometric, physiologic, anthropometric, roentgenologic, and chemical" observations. The plan of the metabolic studies is given in detail with exact directions for the selection and training of the subjects, methods of collection of excreta, sampling of food, urine and feces for analysis, the planning of diets, and the organization of a practical and workable routine. There is a useful discussion of the accuracy of dietary values, and tables are given which show the differences found between calorimetric, chemical, and calculated values. Accounts of the earlier work upon which the present-day standards are based are supplied with copious references. The results treated statistically are included in numerous tables and inserted in these discussions. This method of presentation makes for easier reading of a mass of figures and adds point and value to the figures. Valuable data are included in chapters on digestion, energy metabolism, metabolic balances, and hematochemical studies.

At times the style is difficult and the growing (and lamentable) habit of coining verbs is reflected in "footnoted" and "excerpted." A number of typographical errors mar the usual excellence of a Thomas book. Omission of hyphens and of letters and a few misspelled words and other errors occur. No doubt these mistakes will be corrected in a subsequent printing.

As a guide to methods, this book should be included in the library of every student of metabolism and of nutrition. The suggested modifications for chemical methods are based on the author's experience and should prove useful. One wonders at the inclusion of certain methods in unmodified form since the original methods are available generally. The results in the present volume will be invaluable to the experienced worker in this field; with the additional volume the value to the clinician and to the student will be increased.

The amount of work which these determinations entailed was enormous. Dr. Macy's remarkable gift for organization is apparent in the careful planning of each detail which was necessary to carry out long balance experiments with children from 4 to 12 years of age. The figures on minerals, to cite but one part of the study, give us the story of chemical growth of bone in as complete a form as metabolism methods on living children allow. These figures, together with the information on tissue growth and the development of physiological functions obtained simultaneously, make an important addition to the newer knowledge of nutrition. With a director of Dr. Macy's competence and imagination, these nutrition studies should satisfy even so exacting a scientist as Dr. Carlson.

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Annual Index—Journal of Chemical Education

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The annual index for Volume 19 of the JOURNAL OF CHEMICAL EDUCATION is divided into two parts—an Author Index and a Subject Index, each alphabetically arranged. Letters (Ar), (B), and (C) have been used after the various items to designate, respectively: article, book review, and correspondence. The sections *Out of the Editor's Basket* and *What's Been Going On* are not indexed as to subject material, but contributors to these sections have been listed separately at the end of the Author Index.

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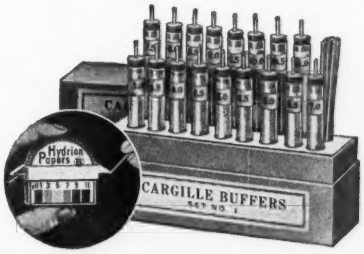

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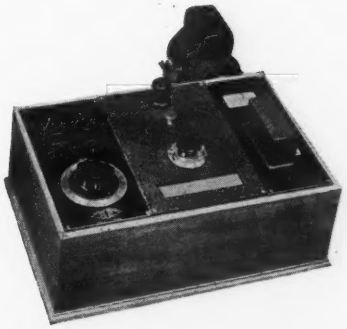
This is the title of a 68-page catalog recently printed in Spanish by *Precision Scientific Company, 1750 North Springfield Avenue, Chicago, Illinois.* It illustrates and describes their complete line of laboratory apparatus. Copies are available not only to our readers in Latin America, but to our subscribers in the United States and Canada who have occasion to use technical publications printed in Spanish.

New Fluorophotometer

A new model Fluorophotometer, designated as Model "C," is announced by *Pfaltz & Bauer, Inc., Empire State Building, New York City.*

According to the manufacturer this instrument is especially designed to accelerate routine control work in the determination of vitamins and minerals, maintaining established standards of accuracy.



The Model "C" is a complete self-contained unit, incorporating a simple electrical circuit, eliminating the use of amplifier and stabilizer. Features of this new model are a novel slide carriage, accommodating both the blank and sample to be tested and an automatic shutter which shields the sample from the light beam and cuts in the measuring circuit. The Model "C" is said to have universal application in fields of fluorometry, colorimetry and turbidimetry using wave lengths of narrow bands over the entire range of the spectrum from 3000 to 8000 A. It may be used either with absorption cuvettes or test tubes.

Literature on the model "C" may be obtained by addressing the manufacturer.

Hevi Duty Carburizer

A 24-page bulletin on the Hevi Duty Carburizer is now available from the *Hevi Duty Electric Company, Milwaukee, Wisconsin.* This bulletin HD-142 is an enlarged and completely revised edition of their bulletin HD-940 of the same title. It will be of particular interest to metallurgists and industrial chemists. Copies may be had free on request.

Acid-Proof Piping

A new bulletin on Acid-Proof Piping, said to be more complete and more comprehensive in its treatment of the subject than anything else previously issued, was recently released by the *U. S. Stoneware Company, 60 East 42nd St., New York, N. Y.* This bulletin, No. 550, illustrates and describes their line of acid-proof piping and fittings. It also contains several pages of engineering and technical data. Copies of the bulletin are available free upon request.

Three Important Books On Organic Chemistry

By E. WERTHEIM, Ph.D.
University of Arkansas

New!

Introductory Organic Chemistry

This 1942 text has been especially planned to meet the needs of students in home economics and agriculture. Its aim is to establish a link between general chemistry and the more specialized and advanced courses which follow, and to ground the student in such fundamentals as an appreciation of the significance of the graphic formula, the importance of the functional groups in the reactions of compounds and the relationships of simple compounds to each other.

Sufficient material is presented to allow the instructor a liberal choice of topics and to give the student a text which will subsequently serve as a reference book. Summaries, review questions and specially prepared charts are included.

82 Illustrations. 482 Pages $3.00 (1942)

Widely Adopted!

Textbook of Organic Chemistry

Intended for students who will major in chemistry or specialize in organic chemistry, and for those who are enrolled in pre-medical or chemical engineering courses, this teachable text presents material for a two-semester beginning course. The salient facts are stated in a definite manner. Numerous cross-references are used to give emphasis to the important relationships between compounds and reactions. Charts and summaries aid in the initial study and facilitate review. Detailed flow sheets illustrate important industrial processes. Portraits and biographical sketches of chemists are included. Tables of physical constants of organic compounds are given. 110 Illustrations. 830 Pages $4.00 (1939)

Successful!

Laboratory Guide for Organic Chemistry *2nd Edition*

This guide presents experimental material for a year's course in elementary organic chemistry. Brief directions for conducting experiments in the identification of compounds, and a short section on "spot tests" are included.

Illustrated. Wire-O-Binding $2.00 (1940)

MELLAN

Organic Reagents in Inorganic Analysis

The sensitive, specific, time-saving and accurate methods employing organic reagents are presented in this book in a genuinely usable way. Limitations are given for each test wherever possible. Interfering substances are listed and instructions are given for elimination of interferences. 243 organic reagents are described; 699 graphic formulas, and 501 procedures are included.

By Ibert Mellan, M.Sc., F.I.C., 682 Pages. $9.00 (1941)

DAVIES

Fundamentals of Physical Chemistry, 2nd Edition

This completely revised text based upon long teaching experience, provides a one-semester course for pre-medical, pre-dental and biology students. Carefully prepared problems, illustrations and exercises are included. The historical approach to the subject has been retained in this edition.

By Earl C. H. Davies, Ph.D., West Virginia University. 78 Illus., 447 Pages. $3.50 (1940)

FOWLES

Lecture Experiments in Chemistry, 2nd Edition

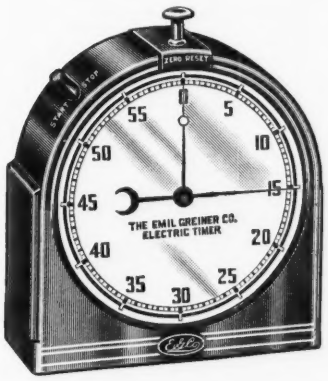
This book describes 547 experiments in chemistry and gives detailed instructions for classroom demonstrations. Notable features of the book are: the simplicity of apparatus employed, notes on reagents, historical data, bibliographies, and the many constructive suggestions for the improvement of teaching.

By G. Fowles, F.C.S. (Lond.). 150 Illus. Tables. 564 Pages $5.00 (1939)

THE BLAKISTON COMPANY, Philadelphia

New

INEXPENSIVE STOP TIMER



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1. A dial face almost twice as large as the usual timers previously obtainable (5½" in diameter).

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3. Graduated in ½ seconds with each full second interval ¼" long, thus making 1/5 or 1/10 second, split seconds easily estimated over these large subdivisions.

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5. Fine instrumentation and accuracy; set in heavy handsome, lacquered metal case; total weight 3¼ lbs.; plug and 4 ft. flexible wire.

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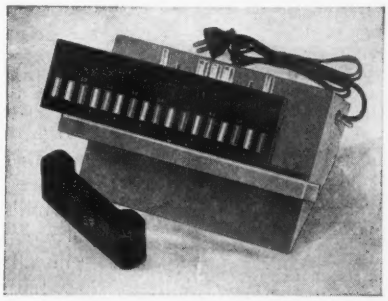
TRADE ANNOUNCEMENTS

Midget Dalite Lamp

While this lamp was designed for use with single Taylor Slide Comparators when determinations must be made at night or in dark places, it has been found to be ideal for all routine testing even in daylight. The Comparator base sits on the shelf at an



angle of 45° so that, in making readings, one can look directly into the slots in the slide and base. This eliminates handling the outfit, with possible chance of breakage, as only the sample tubes need be handled. Also, in many laboratories and plants, it is almost impossible to obtain a clear daylight background because of trees, walls, etc. The lamp gives uniform daylight conditions at all times. It is fitted with a Dalite glass, special bulb, cord and switch and operates on any 110-v. circuit. It can be used with any Taylor pH, Chlorine or Phosphate Comparator. For further information, write *W. A. Taylor & Company, 7300 York Road, Baltimore, Md.*

Chromatographic Tubes

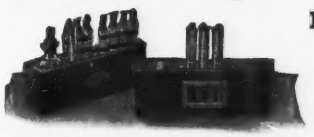
Tubes for use in chromatographic analysis as described by Drs. Zechmeister and Cholnoky in "Principles and Practice of Chromatography" (John Wiley & Sons, Inc., New York), are now being manufactured by *Scientific Glass Apparatus Company, Bloomfield, New Jersey.* Four styles of tubes in six different sizes are available. More information about this new method of analysis and a detailed description of the chromatographic tubes are available in their bulletin No. 155.

Wire Cloth Catalog

A handbook of useful information for the buyer of wire cloth and other woven wire cloth products is published by *Newark Wire Cloth Company, 351 Verona Avenue, Newark, New Jersey.* The handbook contains 116 pages of information on a wide range of wire cloth products. There is a glossary of terms; instructions on how to compute mesh, space, open area; illustrations of weaves; a section on selecting, ordering, and testing.

This handbook is well illustrated and is available if requested on official letterhead.

LaMOTTE pH SERVICE



LaMOTTE BLOCK COMPARATOR

This compact LaMotte Outfit greatly facilitates simple, accurate Hydrogen Ion Control. It is especially recommended for the use of individual operators on any step of a process where a definite pH value must be maintained. Even with highly colored or turbid solutions determinations can easily be made with accuracy.

Complete with any one set of LaMotte Permanent Color Standards, together with a supply of the corresponding indicator solution, measuring pipette and marked test tubes. Complete, $12.50 F.O.B., Towson, Baltimore, Md.

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Dept. Y **TOWSON, BALTIMORE, MD.**

NEW TEXTS for FALL COURSES

Semimicro Qualitative Analysis
New Second Edition

By Paul Arthur and Otto M. Smith, Oklahoma A. & M. College. *International Chemical Series.* In press—ready for fall classes

As in the first edition of this well-known book, the authors constantly maintain the student's point of view, seeking to anticipate his questions and to answer them. The book has been completely revised and largely rewritten. Much new material has been added, particularly in the chapters on theory.

Optical Methods of Chemical Analysis

By Thomas R. P. Gibb, Jr., Massachusetts Institute of Technology. *International Chemical Series.* 385 pages, $5.00

Covers the fundamental theory, the design, and the practical application of the ten optical instruments which are most widely used in organic and inorganic chemical analysis. Emphasis is placed on the design and technique of modern rapid methods of micro and macro analysis by means of the spectrograph, spectrophotometer, colorimeter and allied instruments, refractometer, microscope, and polariscope.

Chemical Technology of Petroleum

By W. A. Gruse, Mellon Institute of Industrial Research, and D. R. Stevens, University of Pittsburgh. *Mellon Institute Technochemical Series.* In press—ready in July

A complete revision of Gruse's *Petroleum and Its Products*, this volume is an almost entirely new book. Every chapter has been rewritten and new chapters have been added on thermodynamics as applied to the problems of hydrocarbon chemistry, production chemistry, etc. A wealth of new material has been added on distillation, physical properties, motor fuels, lubricants, etc.

Chemistry of Engineering Materials
New Fourth Edition

By the late Robert B. Leighou. Revised by J. C. Warner and Associates, Carnegie Institute of Technology. *International Chemical Series.* In press—ready in midsummer

The revision of this standard text covers all the latest information on new materials, covered in new chapters on metallic and inorganic protective coatings, technology of shaping metals and alloys, abrasives, glass, and organic plastics, non-ferrous alloys, alloys of iron, etc.

Heat Transmission
New Second Edition

By William H. McAdams, Massachusetts Institute of Technology. 455 pages, 6 x 9. $4.50

Approximately 85% of the old material has been entirely rewritten and the rest has been thoroughly revised. The purpose of the new edition is threefold: (1) to analyze the data on heat made available by the research of the last decade in the light of the basic mechanisms by which heat is transferred; (2) to present the recommended relations in the form of equations or graphs; and (3) to illustrate the method of attack on new problems.

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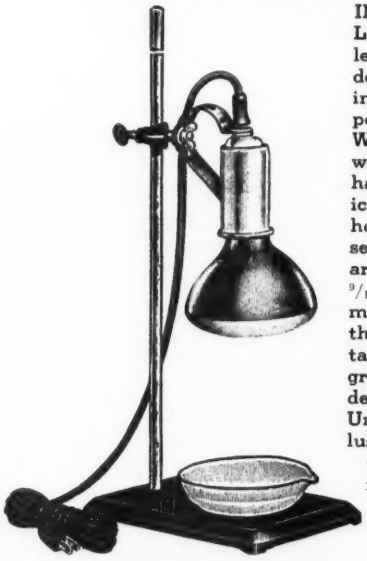
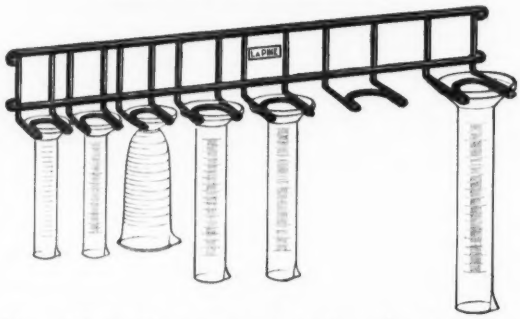


INFRA-RED DRYING LAMP — offers quicker, less expensive, easier dehydrating and drying for dozens of purposes. Uses a G. E. 250 Watt Infra-Red Lamp with integral reflector, having an average service life of five thousand hours. This Heater assembly fits any standard support rod up to 9/16" diameter and by means of a wing nut, the socket can be rotated through 360 degrees vertically and 180 degrees horizontally. Unit is supplied as illustrated, but without the support base and rod, for operation on 105–120 Volts at $3.75. The extra lamps can be furnished at $1.75 each.

LANCO All Purpose Laboratory Knife

For cutting glass tubing, soft glass or Pyrex, rubber tubing, stoppers, corks, etc. Consists of a saw-tooth, double-edged blade of highly tempered steel in metal ferruled wood handle. The cutting edge will hold its sharpness over a long period and will not rust or corrode under ordinary conditions. Cutting edge 3" long, total length 7"...$1.00 each.

LANCO Graduate Rack



Rubber-plated with a generous coating of pure latex to give the ultimate in breakage protection. The LANCO Rack is 24" long, capable of holding seven pieces of glassware ranging from 10 to 500 ml. cylinders or conical graduates, as well as other types of chemical apparatus. Installed by the simplest means in your most convenient location makes the LANCO Rack a laboratory necessity at only.....$2.65 each.

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TRADE ANNOUNCEMENTS

New LaMotte Micro pH Testing Set

A new set with facilities never before offered in the colorimetric system for pH determinations has been announced by the *LaMotte Chemical Products Company of Towson, Baltimore, Maryland.*

It is interesting to note that it requires less than 0.5 ml. of the sample to make the determination and the accuracy of the test is plus or minus 0.1 of a pH. Another feature is that turbidity and color in the sample does not interfere with the pH determination and the actual determination can be made in one minute or less.

The standard set covers the pH range of 5.2 to 8.6 and is available in a compact case which includes all the necessary glassware, indicators, and full instructions for making the test.

Impedance Bridges

A twenty-four-page bulletin entitled "Impedance Bridges Assembled from Laboratory Parts" was recently published by *General Radio Company, Cambridge, Mass.* The booklet gives instructions for setting up and using impedance bridges; tells how to choose the best bridge circuit for a particular type of measurement; and how to determine the magnitude of residual impedance errors. Copies of this booklet, No. 783, are available in reasonable quantities for classroom use.

New Catalog Supplement on Laboratory Glassware

A new 16 page Catalog Supplement on Laboratory Glassware has just been announced by Corning Glass Works.

It introduces many new items and new lines—"Pyrex" Blood Bank Bottles, Lamp Sulfur Determination Apparatus with Fritted Disc, Distilling Receivers with Standard Taper Ground Joints, Bray Type Anaerobic Culture Dish, Lifetime Red Low Actinic Glassware (43 new items) and catalogs "Corning" Alkali Resistant (Boron-Free) Glassware for the first time.

All these new items are now available through regular laboratory supply dealers in the United States and Canada.

A copy of this new catalog supplement may be obtained by writing *Laboratory and Pharmaceutical Division, Corning Glass Works, Corning, N. Y.*

"Heat Transfer Through Metallic Walls"

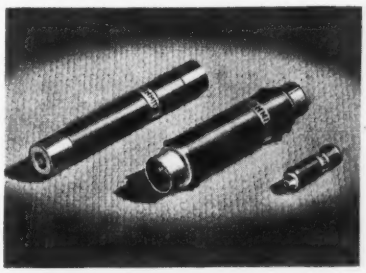
Processing equipment is rarely designed without careful consideration of the overall heat transfer rates that may be anticipated as a result of conductivity through metal walls. Since the thermal conductivities of the metals used in the fabrication of steam chests, condensers, and jacketed units are, of themselves, poor indices of what may actually be expected, considerably more information is desirable to insure successful design.

This 16-page booklet from data prepared by the Development & Research Division of the *International Nickel Company, 67 Wall St., New York, N. Y.*, includes information in formulae for determining overall heat transfer rates, the various factors influencing heat transfer through metallic walls, and the thermal conductivities of metals and alloys commonly used in the construction of process equipment.

To the original data there has been added a number of illustrations showing several types of equipment which are characteristic of process units that depend on the transfer of heat through metallic walls for normal operations.

Ohmite Ferrule Resistors

The Ohmite ferrule resistor has been designed for easy interchangeability without the use of tools. An even winding of resistance wire on a ceramic core is protected by an Ohmite vitreous enamel coating. The wire is terminated on metal bands or ferrules which permit mounting in fuse clips. Ferrules are cup, sleeve, or cartridge type.



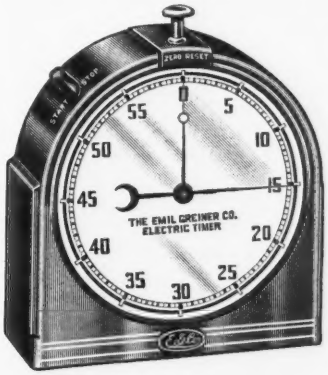
Special ceramic cores are available which, with special coating, will withstand the temperature shock test of repeated immersions alternately from ice cold water to hot water. Protective coatings which pass salt water immersion tests are also available.

The ferrule type of resistor is particularly applicable for use in the Navy, in the Signal Corps, on Army aircraft and on railroads. Units can be supplied in accordance with Navy specifications. Wide range of sizes.

For details write to *Ohmite Manufacturing Company, 4835 Flournoy Street, Department 6K, Chicago, Illinois.*

New Electric Stop Timer

A new electric laboratory timer was recently announced by *The Emil Greiner Co., 161 Sixth Ave., New York, N. Y.* Among the features of this new instrument are a large dial face, $5^1/_2$" in diameter and a perfected frictionless device which is said to give instantaneous start and dead stop without coasting. This



timer is graduated in $^1/_2$ seconds with each full second interval $^1/_4$" long, thus making $^1/_5$ or $^1/_{10}$ second, split seconds easily estimated over these large subdivisions. A large red hand indicates seconds and split seconds for 60 seconds per sweep and smaller black hand for minutes, thus giving reading range up to 3600 seconds for a single revolution of the small hand. A circular describing the timer in more detail is available from The Emil Greiner Co.

Ammonia
Argon
Boron Trifluoride
Butadiene
Butane
Butene 1
Butene 2
Carbon Dioxide
Carbon Monoxide
Chlorine
Dimethylamine
Dimethyl Ether
Ethane
Ethyl Chloride
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Methane
Methyl Bromide
Methyl Chloride
Monoethylamine
Monomethylamine
Nickel Carbonyl
Nitrogen
Nitrous Oxide
Oxygen
Phosgene
Propane
Propylene
Sulphur Dioxide
Trimethylamine

Hitherto, teachers of electronics had to rely chiefly on their own mimeographed material and scattered references!

HERE, IN ONE COMPREHENSIVE VOLUME, IS A COMPLETE COURSE ON THIS VITAL SUBJECT!

EXPERIMENTAL ELECTRONICS

By Ralph Holcombe Muller, Raymond L. Garman and Marcel E. Droz

Massachusetts Institute of Technology

WARTIME emergencies emphasize the tremendous need for men trained in electronics and the application of electron tubes to the complicated process controls used in such industries as refining, milling, tobacco, etc., and in detection devices used in the military services.

EXPERIMENTAL ELECTRONICS covers the principles, uses, and applications of these tubes. It reviews the fundamentals of electrical measurement, and then follows through with "meaty" chapters which completely blanket every phase of this all-important subject.

In the classroom, you no longer need wade through references and mimeographed material. Professors Müller, Garman and Droz have thoroughly covered the ground, weeding out the non-essentials, and now give you a volume destined to become a "must" for all teachers and students of electronics. Professor Müller is one of the most prominent men in the electronic field. In 1940, he was asked by the editors of *Industrial and Engineering Chemistry* to make a nation-wide survey of American instruments and apparatus. His article, *American Apparatus, Instruments, and Instrumentation,* attained instant national acclaim.

EXPERIMENTAL ELECTRONICS

is profusely illustrated with diagrams and drawings showing electronic principles and applications. It contains the following 12 chapters:

1. Introduction (a brief review of electrical definitions essential to understanding electronic circuits)
2. Triodes
3. Characteristics of Photoelectric Cells
4. Power Supplies
5. Multigrid Tubes
6. Characteristics of Gaseous Tubes
7. D.C. Electron-tube Voltmeter
8. A.C. Vacuum-tube Voltmeters
9. Applications of Photocells
10. Untuned Amplifiers
11. Vacuum-tube Oscillators
12. Cathode Ray Tubes

EXPERIMENTAL ELECTRONICS will be published on September 15th. 325 pages, 6 x 9. College list, $3.50.

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TRADE ANNOUNCEMENTS

Distillation Products Ionization Gauge Meter Now Available

A limited number of Distillation Products' new portable Ionization Gauge Meters, Type HG-200, may soon be available, according to an announcement just received from Rochester, N. Y. This new meter, which is designed to operate in conjunction with the Distillation Products Ionization Gauge, Type VG-1, provides a method of measuring pressures from 10^{-3} to 10^{-9} mm. of mercury.

The ionization Gauge Meter circuit features a stabilized amplifier in a balanced vacuum tube of voltmeter design with negative feedback, and an integral amplifier recalibration for elimination of amplifier variation. Other variations in performance are prevented by gas tube voltage regulation and automatic grid current control.

To produce a complete cycle of operation, a switch need only be thrown to de-gas the grid of the ionization tube, while the amplification of the circuit is set to a standard value on the single meter, and the grid current is set to the correct value where the circuit will hold it constant. The plate current can then be read directly from the meter and converted to pressure readings with the factor of the ionization tube. According to the manufacturers the Distillation Products Ionization Gauge, Type VG-1, used in this arrangement, has a high sensitivity of 200 microamperes per micron.

The circuit which is already in use on many production systems, including the exhaust of large transmitting tubes, has proved itself to be reliable and rugged. The meter is simply designed so that it can be handled by nontechnical employees.

Furnished in a cabinet of gray-crackle finish, the unit comes complete with all necessary cords and plugs, and ionization tube ready to seal onto any Pyrex system. It operates on any 110–115 volt, 60 cycle line.

Bulletin on Gas Cracking Unit

A new bulletin HD 1042, "The Hevi Duty Gas Cracking Unit" is now available from *Hevi Duty Electric Company, Milwaukee, Wisconsin.* The bulletin illustrates and describes the Hevi Duty Gas Cracking Unit which is designed to produce a protective atmosphere for use during the heat treatment of alloy and high carbon tool steels, particularly those containing molybdenum.

"Curves and References"

An eight-page bulletin called "Curves and References" has recently been published by *Wilkens-Anderson Company, 111 North Canal Street, Chicago, Ill.* The bulletin discusses the uses of the Coleman Universal Spectrophotometer in the analysis of various metals, foods, vitamins, etc. Copies of the bulletin are available on request.

"Priorities and Requirements in Obtaining Laboratory Supplies"

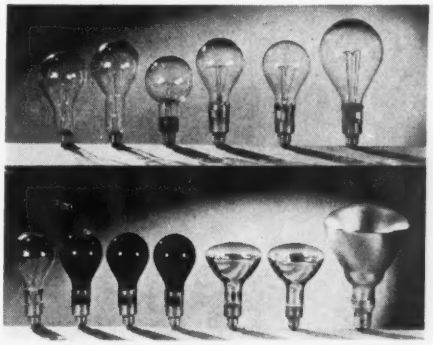
The current issue of the "Laboratory" contains an excellent article on "Priorities and Requirements in Obtaining Laboratory Supplies" which should be read by every user of laboratory apparatus. Copies of the "Laboratory" are available on request from the publisher, *Fisher Scientific Company, 711 Forbes Street, Pittsburgh, Pa.*

Bulletin on Gas Analysis Apparatus

A bulletin, No. 40–97 on the new "Build-Up" Models of Burrell Gas Analysis Apparatus is available from the *Burrell Technical Supply Company, 1936–42 Fifth Avenue, Pittsburgh, Pa.* The bulletin illustrates and describes a number of the portable and laboratory "Build-Up" Models.

New Infra-Red Heat Lamps

A new line of infra-red heat lamps, designed in keeping with the limitations imposed by the War Production Board, has just been announced by the *Birsdeye Division of the Wabash Appliance Corp., Brooklyn, N. Y.* The new line includes six clear types, three ruby types, and four reflector types. All feature the M-type tungsten filament for uniform heat distribution and have their bases reinforced with asbestos-lined mechanical straps to withstand the terrific temperatures of tunnel installations. The reflector types have built-in reflector linings of pure silver sealed inside the bulbs for protection against dimming and tarnishing by fumes or dirt. Average burning life on all is said to be in excess of 6000 hours.



Infra-red lamps are being used to speed up baking, drying, and dehydrating in war industries. The Birdseye heat lamps produce infra-red and near infra-red rays that are converted into a deeply penetrating kind of heat as soon as they strike an object. Instead of heating from the surface slowly inward, the action is reversed—the infra-red rays penetrate deep down into the surface films of lacquers, paints, and enamels to start the baking process from the inside out, instantly and uniformly.

Advantages claimed for infra-red are speed, ease of operation, and economy. Initial investment is low because infra-red equipment is relatively inexpensive and is quickly and easily installed. Infra-red is apparently as easy to use as regular light bulbs, as a flip of the switch brings the heat in full force immediately. Since lamp installations are lightweight, they can easily be moved, and since they are compact, they usually occupy little floor space. The entire subject is covered in new literature being issued by the *Wabash Appliance Corp., 345 Carroll Street, Brooklyn, N. Y.*

Determination of Palladium

REAGENT—β-Furfuraldoxime

METHOD—Gravimetric

REFERENCE—Hayes and Chandlee, *Ind. Eng. Chem., Anal. Ed., 14,* 491 (1942)

Palladous chloride forms with β-furfuraldoxime a co-ordination compound having the formula $Pd(C_4H_3OCHNOH)_2Cl_2$. This water-insoluble compound can be filtered, dried, and weighed in the usual manner, giving accurate results for amounts of palladium ranging from 2 to 30 mg.

This procedure is feasible for the determination of palladium in the presence of other platinum metals and the more common metallic ions. Anions other than chloride do not interfere. Only gold and ceric ions, and metals forming insoluble chlorides, need be removed. The reagent is available as *Eastman 2907 β-Furfuraldoxime, MP 88-90°.*

Write for an abstract of the article in which the determination of palladium with β-furfuraldoxime is described. . . . Eastman Kodak Company, Chemical Sales Division, Rochester, N. Y.

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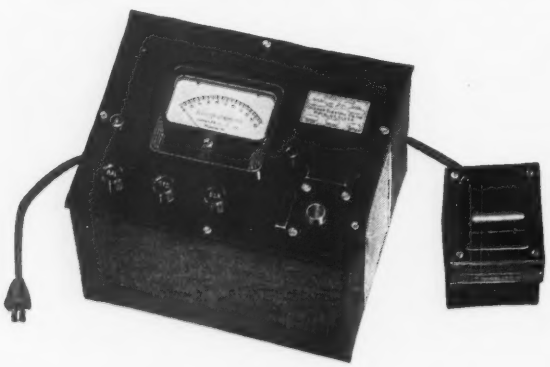

WRITE FOR BULLETIN C-103

COLEMAN ELECTRIC CO.

310 Madison St.
Maywood, Ill.

415 Lexington Ave.
New York, N. Y.

THE MODEL 12 PHOTOFLUOROMETER is intended primarily for the fluorescence analysis of Vitamins B_1 and B_2, but is equally adaptable to quantitative measurements of other fluorophors, such as porphyrin and metal complexes. It was especially designed to overcome the recognized limitations of older type fluorescence meters.

In Model 12 the usual barrier layer photocell and galvanometer is replaced by a true high vacuum phototube, electronic amplifier and rugged, wide scaled meter. Two carefully aligned lens systems so direct the light that full precision is enjoyed with only 8 ml of sample in an ordinary 3/4" test tube. The result is a fluorescence meter of unparalleled performance: sensitive, fast, precise, rugged—entirely practicable both for the Researcher and for the busy control laboratory, where errors are expensive and where minutes count.